IMPACT OF COAL MINING ON WATER QUALITY

A THESIS SUBMITTED IN PARTIAL FULLFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology

In

Mining Engineering

By

GAURAV KUMAR

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DEPARTMENT OF MINING ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

ROURKELA – 769008

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Under the guidance of

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NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA

CERTIFICATE

This is to certify that the thesis entitled **"Impact of coal mining on water quality"** submitted by Sri Gaurav Kumar(Roll No. 111MN0073) in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

Date:

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ABSTRACT

Introduction

Water is one the basic needs of the mining industry. All the operations of mining, directly or indirectly require water for their functioning. The mining industry has been utilizing water carelessly without anticipating the negative impacts it is having on the ecology and the bio-diversity of the region. Acid mine drainage has become a common phenomenon associated with mining. Deaths and diseases caused by contaminated water has roused concerns everywhere. The critical situation requires carrying out water analysis of all the water bodies in and around the mines to determine the source, cause, effect and remedies of the different contaminants and pollutants. This is also a part of the corporate social responsibility that the mining industry has pledged to. This also helps in reassuring the people of the pro-development motives of the mining industry.

Experimental

The samples are collected from two different coal mining regions, IB Valley and Talcher area, of the state of Odisha. The analysis was carried out to find the effect, coal mining activities were having on the water quality of the mines. The purpose was also to compare the effects on the water quality of the two different mines from different regions. The parameters that were determined for this purpose are temperature, pH, conductivity, TDS, DO, BOD, turbidity, acidity, sulphates, phosphates, sodium, potassium, calcium, magnesium and other trace metals.

Observation: The experimental results gave the following readings of different parameters.

SL NO.	PARAMETER	IB VALLEY			TALCHER AREA			ETP	
		SL- 1	SL-2	SL- 3	SL- 4	SL- 5	SL- 6	SL-7	SL-8
1	pH	5.02	4.45	4.82	3.6	6.12	4.37	6.85	7.02
2	Turbidity (NTU)	45.6	237	311	8.1	10.6	22.6	8.71	8.03
3	DO (mg/l)	10.48	8.85	7.88	7.83	7.81	7.42	5.95	9.14
4	BOD (mg/l)	2.11	0.88	1.07	2.7	1.4	1.2	0.86	0.03
5	TDS (g/l)	0.089	0.274	0.316	0.483	0.656	0.416	0.264	0.24
6	Hardness (mg/l)	100	919	35.71	476.19	500	414.29	42	121
7	Phosphate (mg/l)	3.179	3.247	3.214	BDL	BDL	0.17	2.88	2.21
8	Sulphate (mg/l)	92.77	177.629	82.592	98	86	189	168	157
9	Fluoride (mg/l)	0.3	0.4	0.5	0.5	0.5	0.5	5	1
10	Sodium (mg/l)	3.791	5.382	3.198	24.75	21.52	27.52	21.5	13.6
11	Potassium (mg/l)	0.290	16.63	3.885	10.19	10.06	14.81	12	6.22
12	Cadmium (mg/l)	0.005	0.006	0.004	0.004	0.007	0.005	0.004	0.003
13	Copper (mg/l)	BDL	BDL	BDL	0.032	0.026	0.046	BDL	BDL
14	Calcium (mg/l)	11.43	62.04	15.88	70.38	67.52	45.4	17.9	34.7
15	Silicon (mg/l)	0.164	3.552	3.673	5.474	5.180	5.465	6.39	4.212
16	Cobalt (mg/l)	0.006	0.197	0.011	0.008	0.011	0.014	0.013	0.015
17	Selenium (mg/l)	0.037	0.036	0.016	0.115	0.079	0.115	0.07	0.087
18	Magnesium (mg/l)	8.755	48.14	19.02	30.45	31.18	38.9	86.3	24.1

Conclusion:

In the above table we find that SL-1 to SL-6 all have low pH values showing their acidic nature i.e. their pH value is less than 5.5. SL-5 has slightly higher TDS values than the permissible limits (TDS > 0.5g/l). The BOD values show good results i.e. they are within the limit (BOD<3 mg/l). SL-2, SL-4, SL-5, SL-6 have high hardness values putting them in the hard water category. This is consistent with the magnesium readings (>30 mg/l) which is also very high and maybe the reason for the hardness of the water. The selenium concentrations in all the samples are above the permissible limits (>0.01 mg/l). This clearly shows that the soil contains high selenium content. The rest of the parameters all lie within the permissible limits and pose no threat to the environment.

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CHAPTER 1

INTRODUCTION

1. INTRODUCTION

Water is the principal need of life on earth and is an essential component for all forms of life, from micro-organisms to man. The world's water resources are under pressure and must be managed for human survival. The need for physio-chemical analysis of water is very vital and all sources of water must be known before consumption. Mining of coal deposit all over the world are being carried out under complex hydrogeological environments causing a range of water problems affecting the production and utilization cost. Water pollution has now reached a crisis point. Almost every water body is polluted to an alarming level. The estimation of quality of water is extremely important for proper assessment of the associated hazards. The extensive mining activities also adversely affect the environment. Due to lack of proper planning and negligence of regulations an appreciable amount of environmental degradation and ecological damage to water air, and soil occurs. The problems associated with mining activities are land degradation, disposal of overburden, deforestation, washing rejects, subsidence, water pollution due to wash off, discharge of mine water, acid mine drainage, coal washing operation, air pollution due to release of gases and dust, noise pollution, mine fires etc. Water pollution from coal includes negative health and environmental effects from the mining, processing, burning, and waste storage of coal, including acid mine drainage, thermal pollution from coal plants, acid rain, and contamination of groundwater, streams, rivers, and seas from heavy metals, mercury, and other toxins and pollutants found in coal ash, coal sludge, and coal waste. Water contamination is inevitable. It is bound to occur due to the presence of various minerals in the rock. Our efforts should concentrate on checking the pollution levels of different parameters and keeping it within the prescribed standards. As far as concerned, water pollution due to man-made activities should be prevented in the best possible manner. This is where coal mining has the biggest impact. Our actions are not checked. In our endeavor to meet our demands and fulfill targets, we fail to realize the impact our actions can have on the environment. We also fail to realize the proper and safe use of resources around pollution prone areas. We must adopt methods that are less prone to damaging the environment, in particularly the water bodies, both the nearby and the far away ones. For this purpose a complete survey of the water bodies in the mining area should be carried out to understand the challenges that need to be faced. Water quality analysis gives an overall picture of the quality of water present in the mines. It helps identify the areas of concern, the parameters

which are most harmful, contaminants which pollute the most and the areas which cause the contamination. In short it helps in identifying the source, the causes and the effects. This helps in finding out the methods to reduce the damages. It also helps to carry out measures which prevent the contamination in the near future. To get a good idea of the water quality in the mines, analysis has to be carried out systematically and in a pre-planned manner since parameters change with changing environment. The samples have to be preserved in a proper manner to get near accurate results. A number of methods have been designed for this purpose. Different institutions have come with different levels of permissible limits for various parameters.

1.1 Objectives of the study

1. To collect water samples from coal mining areas
2. To analyze the water samples for their various chemical content
3. To identify the threats by comparing them the standard chart
4. Compare the samples from two different coal mining areas

CHAPTER 2

LITERATURE REVIEW

2. LITERATURE REVIEW

Pathak and Banerjee (1992) carried out water analysis in Chapha incline of Umaria Coalfield in eastern Madhya Pradesh to determine the water quality parameters including trace element detection and microbial analyses. Sampling at the site of investigation was done by random selection so that the composition of the sample was identical to that of the parent water body. The samples were collected before the monsoon period as well as after corresponding to low and high water table conditions. The physio-chemical analysis of water comprised determination of the following parameters; turbidity, pH, total alkalinity, total dissolved solids, dissolved oxygen, Biochemical Oxygen Demand, chloride etc. To calculate WQI, an approach similar to Horton (1965) was followed. Trace metals were determined by Atomic Absorption Spectroscope. From the results it was found that the coal mine water was severely polluted. Parameters like turbidity, BOD, alkalinity and bacterial colonies were not within permissible limits as compared to standards. High cationic and anionic concentrations were also noticed. They concluded that the mining operations were having degrading effect on the WQI.

Dharmappa et al (1998) carried out the analysis of water quality in the Illawarra coal mines, NSW, Australia to study the waste water quality management of the mines. A total of 12 water sampling and monitoring points were established for 3 months and 6 months interval monitoring periods. The parameters that were measured are pH, electrical conductivity, non- filterable residues, total dissolved solids and barium. The general water quality management at the site as well as the waste water treatment performance were assessed using the above parameters. The test results showed that the wastewater though neutral in pH had high conductivity and total dissolved solids classifying it in class 3 i.e. characterized the water as highly saline and hence unfit for irrigation. The investigations on the treated waste water revealed neutral pH, low suspended solids content, low to medium conductivity and medium total dissolved solids thus placing it as class2 i.e. medium saline water and hence approved for irrigating soils of moderate draining characteristics.

Khandelwal and Singh (2005) attempted to predict the chemical parameters like sulphate, chlorine, chemical oxygen demands, total dissolved solids and total suspended solids in mine water using artificial neural network (ANN) by incorporating the pH, temperature and hardness. The prediction by ANN is also compared with Multivariate Regression Analysis (MVRA). For this purpose a total of 30 data sets were taken for the training of the network while testing and validation of the network was done by 10 data sets. The prediction of results of chemical parameters of mine water by ANN were very satisfactory and acceptable as compared to MVRA and seems to be a good alternative for pollutants prediction.

Singh (2008) investigated water samples from Jharia, Raniganj and Northeastern Coalfields to study the impact of coal mining on water quality from underground mines of Indian coalfields. Standard methods were used for analysis. The pH and conductivity values were measured using Philips pH-meter and systronics Conductivity Bridge respectively. Iron was estimated spectrophotometrically using VS U2 spectrophotometer. The quantitative analyses of trace metals were done using atomic absorption spectrophotometer, SP 1900. The results showed that the underground mine waters were neutral to slightly alkaline and pH values lied within permissible limits. Chloride concentrations were low and within permissible limits. Sulphate concentrations exceeded the permissible Public Health Standards. Trace metals were found to be either completely absent or present in quantities less than 0.1 mg/L.

Xu and Gao (2009) assessed the water quality in Huainan and Panyi coal mine to provide the theoretical basis for comprehensive utilization of coal mine subsided water resources. 36 sampling pints using grid technique and GPS for accuracy were calculated for collecting water samples. Water temperature, pH value, clarity, dissolved oxygen etc. were measured onsite and for heavy metals were analyzed in the laboratory. Ion chromatography, inductively coupled plasma atomic emission spectrometry, atomic absorption spectrophotometry etc. methods were used. Fuzzy evaluation method was to conduct comprehensive evaluation of its water environment and the standard for evaluation criteria used was GB3838-2002. The results showed that the two subsided

areas in the Hainan Panyi area were both polluted with different degree with the west bank being lesser polluted than the eastern bank.

Atkins et al (2010) analyzed the water quality in the aquifers of the Thar lignite deposit in Sindh, Pakistan to improve the life of the people inhabiting the nearby areas. Water samples were collected both from top and bottom aquifer from shallow water wells and boreholes. PH values were determined using a pH meter. Conductivity and TDS were used to determine total dissolved solids and conductivity of the sample. A spectrophotometer was used to determine the hardness and ions of various elements. The test results indicated that the aquifer can be classified as (sodium, potassium) chloride type water with a TDS range of 1000 to 2000 mg/L. there was no detection of heavy metals and toxic metals including arsenic, mercury and lead or cyanide. The aquifer classified as brackish (saline water) was required to undergo treatment before it can be utilized for domestic or industrial consumptions.

Carlos et al (2011) studied the impact of coal mining on water quality of three artificial lakes in Morizini River Basin. Sampling was carried out in two seasons, summer and winter of 2003. Principal component analysis was carried out to identify possible relations among lakes, depth, and season. The analysis was based on a product moment matrix obtained from a range standardized matrix. The physical and chemical variables selected for the PCA were temperature, total solids, calcium, aluminium, silicon, iron, zinc, nickel, pH, electric conductivity and dissolved oxygen. The results showed that pH increased with depth ranging from 5-7; the pH being slightly higher during winter. The electrical conductivity values were high ranging from 700 to 900 µs cm^{-1} in both periods. DO values were lower during summer. Total solids concentrations were higher in Lake 1 and 2 than in Lake 3. So_4^{2-}, Ca, Mg and K concentrations were higher in Lake 1 and 2 than in Lake 3. The data observed showed that coal mining has made a strong environmental impact.

Muthangya and Samoei (2012) assessed the quality of water due to mining activities in coal rich Mui Basin on Kitui County, Kenya. 9 sampling points were chosen from shallow open wells and boreholes to collect water samples. Mapping of the location of the selected shallow wells as well as the boreholes was carried out by use of a high sensitivity GPS navigator, GARMIN eTrex Legend HCx. The pH, electrical conductivity, resistance, total dissolved solids and salinity were determined using SANXIN Model SX751 while the cationic composition were determined

according to standard methods in an atomic absorption spectrophotometer. The results showed that the samples were alkaline but within guidelines suggested by WHO. The conductivity was high ranging from 1600 - 3700 micro Siemens/cm at 25^{o}C which is outside the permissible limit. TDS values varied from 635 – 2637 outside the 500 – 2000 mg/L prescribed limit.

Verma et al (2012) analyzed the water sample of pond located near Nandani Mines in Durg district, Chhattisgarh. For the purpose sampling strategic locations were plotted and water samples were collected in plastic bottles and transported immediately to the laboratory. The water samples taken from the pond were analyzed for BOD, TDS, COD, nitrate, chlorine, iron sulphide, magnesium, calcium, carbonate, PO_4, NH_3. The observed values of various physiochemical parameters of water samples were compared with the standard values recommended by World Health Organization for drinking purposes. It was found that the pond water was slightly alkaline and hardness was high. The TDS value was 1970 mg/L. the values were also compared to tap water samples and were found to be quite higher in comparison. They concluded that the pond water was unsafe for drinking because of contamination by nearby mining activities.

Zakir et al (2013) assessed the water quality around Barakpuria opencast coal mine for suitability in domestic, industrial, livestock and irrigation use. 26 water samples from different water sources (19 mine water and 7 ground water sources samples) were collected from different sides of Barakpuria coal mine area. The samples were analyzed in the laboratory for pH, electrical conductivity, total dissolved solids, dissolved oxygen, major cations & anions and trace elements. Methods such as AgNO3 titration, titration with standard H_2SO_4, flame photometry, spectrophotometry, atomic absorption spectrophotometer etc. were used for analysis. Parameters such as sodium absorption ratio (SAR), soluble sodium present (SSP), residual sodium carbonate (RSC), permeability index (PI), and hardness were calculated to evaluate the suitability of water quality for the agricultural purposes. The analysis showed the water samples to vary from neutral to little alkaline, high values of EC, TDS, TH, HCO3-, Cl-, SO42- and K. Among the trace metals Fe, Zn, Cu and Mn analyzed, Mn content was found to be dominant. The nearby areas were found unfit for irrigation due to high values of salinity and alkali hazard (SAR), RSC, SSP and PI.

Sandipan et al (2013) assessed the ecological status and seasonal variation of surface water parameters of opencast coal pit lakes in Raniganj Coalfield area. Water samples were collected from four different OCP at strategic locations and mixed thoroughly before analysis. The sampling procedure and analysis was carried for 3 consecutive years on regular basis seasonally. Parameters like temperature, pH, electrical conductivity, free carbon dioxide, dissolved oxygen and primary conductivity were analyzed on time in the field. The rest of the parameters were analyzed in the laboratory. It was found that the surface water quality in the abandoned mines were alkaline, soft to moderately hard and fresh in nature. The rest of the parameters were within permissible limit hence the pit could be used as a reservoir and its water for various purposes.

Dwivedi et al (2014) studied the pollution levels in Hasdeo River due to coal mining activities nearby and assess it for its portability. Water samples collected from three different locations on the river in Korea district and analyzed for parameters such as pH, alkalinity, hardness, sulphate, fluorite and chloride concentrations, total oxygen and total dissolved solids. The samples were analyzed in the laboratory for physio-chemical properties. It was found that all the tested parameters were within the permissible limit and there was no adverse effect on the waste quality of the river.

CHAPTER 3

IMPACT OF MINING ON WATER QUANLITY

3. IMPACT OF COAL MINING ON WATER QUALITY

Use of water in coal mining

Water as a resource is integral to process of extraction of coal both from surface and underground mines. Operations such as coal cutting in underground mines, dust suppression, coal preparation, coal washing, domestic use in mines, etc. The mines usually salvage the ground water to meet their demands and in the absence of ground water, they acquire water from the nearby water resources.

Impact of coal mining

Coal mining activities can directly affect the quality of the water or indirectly through processes which may show its consequences at a later stage in the life of the mine. The gravity of the impact of these activities depend on a number of factors like the geology of the area, the mineral constituents of the coal, the composition of the overburden, scale of operations, rainfall distribution, etc. Some of the major sources of water pollution in coal mining areas are

1. Mine water drainage/Acid mine drainage

   Coal seams sometimes have high concentration of pyrites which in presence of water and oxygen undergo oxidation to give sulphuric acid thereby increasing the acidity and pH of the water used. This water contaminates the other water bodies and the ground water when discharged from the mine.

2. Loose material runoffs

   The process of mining is usually associated with generation of large amount of dust and, the mineral and overburden excavated are converted to loose material. Winds pick up these dust particles along with loose material and deposit them on water bodies. Loose material is also carried by the streams running through the mines which eventually meet the main course or end into a water reservoir causing pollution in both cases.

3. Oil and fuel spills

   Oils and fuels are used for the machinery and equipment used in the mining operations. These oils and fuel sometimes leak away or washed off during cleaning and maintenance.

The water used for washing or during rains, these oils and fuels contaminate the nearby water bodies.

4. Pollutant leaching from overburden dump

   Overburden dump is the waste material which has to be removed before the mineral resources can be salvaged. The waste materials can contain pollutants in the form of heavy metals of other chemicals which leach out during the rains and pollute the surrounding areas.

5. Sewage discharges

   A mine employs hundreds of people, who's domestic and sanitary water needs have to be taken care of. The sewage from the domestic and sanitary use of water can cause pollution if they discharges untreated.

3.1 Environmental impacts

i. The mines acquire natural water reservoirs to fulfill their needs. These reservoirs are sometimes the only source of usable water for the people for their domestic and agricultural needs. With added pressure of the need of the mining industry, the water resources deplete at an alarming rate leaving the people in turmoil.

ii. Mining involves the use of large amount of water, the source of which sometimes ids the ground water. The large scale use of the ground water results in lowering of the water table creating problems for the nearby regions who use wells and hand pumps for their water supply. Also, in underground mining the development process may come in level with the water table during which the water has to be removed or diverted causing destruction of the water table in both cases.

iii. The water used in mines is are sometimes left untreated within the mines itself. These untreated waters can percolate through the soils and contaminate other water bodies. Even if the water is undergone treatment but the treatment plant has not been built properly, it can lead to the same result.

iv. The poor quality of water of mines eventually affect the nearby streams and rivers.

v. Polluted water can affect the bio-diversity of the area. Increase or decrease in pH of the water can affect or prevent the growth of the plants in the area. Similarly, increase in other physical and chemical parameters directly or indirectly affect vegetation of the area. With no vegetation and contaminated water the wildlife also faces the brunt.

3.2 Health impacts

i. The consumption of such waters can lead to severe health problems, diseases and even deaths in some cases.
ii. Different contaminants affect different portions of the body individually and collectively.
iii. Consumption of water containing lead beyond permissible limits causes neurological disorders with most cases ending up in deaths.
iv. Similarly there are trace metals like arsenic, cadmium, cobalt, copper, iron, etc. which can severe damages to the nervous system.
v. The major health problems associated with water contamination are gastro-intestinal irritation, dental and skeletal fluorosis and methaemoglobinemia.

CHAPTER 4

SAMPLING

4. SAMPLING

4.1 Collection and preservation of samples

Sampling is carried out to obtain representative samples. The representative samples should mirror the environment in which it is present i.e. the concentration in the surrounding area should be similar to that present in the sample taken. Additionally the area should be so selected that it reflects the impact of the mining operations taking place in the area. The water body from where the samples are taken should not be isolated rather it should be within the confines of the mining area and linked to the operations directly or indirectly.

The samples so collected should be handled carefully such that no significant changes takes place between the time of collecting the samples and the measurement of the different parameters. For this the sample should be stored in a laboratory with proper preserving facilities as soon as possible. To obtain accurate results and representative data, collection of the water sample should be pre-planned and done in a systematic manner rather than just randomly. Thus prior consultation should be taken before carrying out any sampling to guarantee selecting specimens which would depict the scenario of the area and give a representative sample to carry out the tests for which answers are sought.

4.2 Basic guidelines

- A sample is obtained as per the sampling program such that it does not deteriorate or get contaminated before it is analyzed.
- Sampling equipment and containers should be clean, reliable and free of contaminants before use.
- Pre-rinsing with sample should be avoided as it results in loss of any pre added preservative which affect the results since certain components may stick to the sides of the container.
- For samples containing organic compounds and trace metals special precautions should be taken since they are usually present in small concentrations and if proper sampling and preservation is not adhered to, it may result in wrong readings.

- For composite samples there is no universally applicable recommendations since it can vary with time, depth and place depending on the local conditions. So composite samples can be collected as applicable.
- For determination of metals it is recommended that ultrapure acid be added to the sample to bring the pH to less than 2 to prevent contamination or precipitation of the metals.

4.3 Types of Samples

a. Grab samples: A sample taken spontaneously to represent the overall surrounding environmental features including the composition of the water, air, or soil only at that time and place. They are single samples collected in a short period of time from a specific spot at a site to represent the area at particular time.

Thus, they represent a "snapshot" in both space and time of a sampling area. Discrete grab samples are taken at a selected location, depth, and time. Depth-integrated grab samples are collected over a predetermined part of the entire depth of a water column, at a selected location and time in a given body of water.

b. Composite samples**:** They are number of single samples taken from the same area to give results on an average. This is done when the variations within the same is large and a single sample cannot give an overall picture of the location. They can also include sampling over a long period of time at certain intervals to imbibe the variations that place with time. Composite samples can be obtained by combining portions of multiple grab samples or by using specially designed automatic sampling devices.

4.4 Sampling Methods

a. ***Manual sampling:*** Manual sampling involves minimal equipment but may be unduly costly and time-consuming for routine or large-scale sampling programs. It requires trained field technicians and is often necessary for regulatory and research investigations for which critical appraisal of field conditions and complex sample collection techniques are essential. Manually collect certain samples, such as waters containing oil and grease.

b. ***Automatic sampling:*** Automatic samplers can eliminate human errors in manual sampling, can reduce labor costs, may provide the means for more frequent sampling and are used increasingly. Be sure that the automatic sampler does not contaminate the sample. For example, plastic components may be incompatible with certain organic compounds that are soluble in the plastic parts or that can contaminated (e.g., from phthalate esters) by contact with them. If sample constituents are generally known, contact the manufacturer of an automatic sampler regarding potential incompatibility of plastic components.

4.5 Sample Collection

The samples are collected from two coal mines belonging to two different coal mining areas i.e. IB valley region and Talcher region. The samples are collected from three different points on the nallah through the mine. The 7^{th} and 8^{th} samples are collected from the inlet and outlet of effluent treatment plant belonging to one of the mine in the region. For each sample, two 1-litre bottles were used.

Table-4.1: Details of water samples collected

Sample no.	Place from where sample was collected
Sample 1	Upstream nallah of first mine
Sample 2	Downstream nallah of first mine
Sample 3	Confluence point of first mine
Sample 4	Upstream nallah of second mine
Sample 5	Downstream nallah of second mine
Sample 6	Confluence point of second mine
Sample 7	ETP inlet
Sample 8	ETP outlet

FIG-4.1 Sampling area of SL-1, SL-2 and SL-3

FIG-4.2 Sampling area of SL-4 to SL-8

FIG-4.3: Location of Sample-1

FIG-4.4: Location of Sample-2

FIG-4.5: Location of Sample-3

FIG-4.6: Location of Sample-4

FIG-4.7: Location of Sample-5

FIG-4.8: Location of Sample-6

Fig-4.9: Location of Sample-7

FIG-4.10: Location of Sample-8

CHAPTER 5

WATER QUALITY ANALYSIS

5. WATER QUALITY ANALYSIS

Water is among the most important components that make our life. It consumption and use in our day to day life has made it the most important commodity. Though our earth comprises of 71% water, only 2.5% of it is freshwater of which 98.8% is glaciated. Thus we are surrounded by very little amount of consumable water. The quantity part of the water has been figured out. Now, it is important to figure out the quality of the water. Not all rivers, streams, lakes, ponds, etc. contain water that can be consumable. The physical characteristics somewhat help in analyzing the quality of the water but it does not give the overall picture. Some waters may look fine when judged just by their physical parameters but it is not always so. There are some contaminants that are not visible to the naked eye. This is where water quality analysis comes in. Water quality helps in analyzing each and every element that can be a contaminant and thus a danger to life, the environment and the ecosystem.

It important to analyze both the physical and chemical parameters of the water to ensure that the water is well within the standards for safe consumption as well to preserve the surrounding ecosystem from degradation from the contaminants. In situations where permissible limits are exceeded, the analysis helps take remedial measures and that too proper measures with right the combination of chemicals if need be. The following instruments have been used for the analysis of various parameters.

5.1 Multi Water Quality Checker

The multi water quality checker is a simple device that allows maximum of 11 simultaneous measurements for various parameters. It has integrated control unit and sensors. The device design allows for easy on-site measurement with a variety of functions to measure the water quality of river water, waste water and ground water.

Calibration

1) The sensor guard is removed and the sensor probe is washed with distilled water several times.
2) The transparent calibration cup is removed.
3) The calibration cup is filled with a pH 4 standard solution up to the mark.
4) Select the Auto Calibration option under CAL and dip the sensor into the standard solution in the transparent calibration cup.
5) The black calibration cup is placed over the transparent cup and the ENTER key is pressed to begin calibration after all the values have been stabilized.

Procedure:

1) The sensors are checked and washed with distilled water.
2) The option "SINGLE MEASUREMENT" is selected.
3) The sensor is then dipped into the sample such that no air bubbles remain around the sensors.
4) Once the readings have stabilized, the MEAS key is pressed to acquire the 5- second average.
5) The measurement is saved by pressing the ENTER key.

5.2 Flame Atomic Absorption Spectrophotometry

Atomic absorption spectrophotometry is an instrument that is used for quantitative analysis of different elements in water as well as solids. Its works on the principle that each metal has a characteristic wavelength in which absorbance takes place. The sample is atomized by aspirating into a flame. A beam of light is allowed to pass through the flame and received by a monochromator which singles out the specific wavelength and then falls on to a detector which records the amount of light absorbed by the atomized form of the sample.

Apparatus

i. Atomic absorption spectrometer
ii. Burner
iii. Lamps
iv. Pressure reducing valves
v. Vent

Procedure

1. The apparatus is set and adjusted according to manufacturer's guidelines.
2. Flame is generated using acetylene and stabilized.
3. Calibrate the apparatus by aspirating the blank solution containing the same amount of acid as in the standards and samples.
4. At least three standards are aspirated and its absorbance measured.
5. The samples are then aspirated in the flame, its absorbance measured and the concentration is calculated and displayed on the screen.

5.3 Flame Photometry

Flame photometry or flame emission spectroscopy is an atomic spectroscopy like the atomic absorption spectroscopy that requires no light beam to measure the concentration. It directly measures the emitted wavelength when the atoms are transitioning from excited to ground state. For the conversion of the atoms from ground state to excited state a flame is used unlike in the absorption technique where a lamp is required.

In the atomic emission spectroscopy, a jet of compressed gas is used to convert the samples solutions to aerosol form which is atomized by a flame, carried to, by the flow of the gas. In the process of atomization the metal constituents of the samples are converted to gaseous atoms, which are then ionized. The electrons absorb the heat from the flame and get excited to a higher state. On returning to the ground state, each metal emits light of specific wavelength which can be detected and used to find the concentrations of the metals.

Procedure

1. The standard solutions are samples are prepares accordingly.
2. The apparatus is set according to the manufacturer's guidelines.
3. Initially distilled water is used for blanking.
4. The standards are then analyzed and their absorbance readings noted.
5. The samples are then aspirated to get their absorbance readings.
6. A graph is plotted between the concentration of the standards and their absorbance readings.
7. Using the absorbance reading of the samples and the plot obtained the previous step, the concentrations of the element in the samples can be obtained.

Parameters and their significance

Temperature: Temperature defines the rate of chemical and biological processes that occur in water. Sustainability of living organisms also depend on water. Some prefer cold temperatures, some prefer warmer conditions while most survive in the mild temperature as it affects their biological and ecosystem directly or indirectly. For example the oxygen content in water decreases with increase in temperature which then goes on to affect the photosynthesis of aquatic plants, the metabolism rates of organisms.

Apparatus: Multi water quality checker

Procedure: as given in section 5.1

Observation: As per given in Table No. 5.1

Conductivity: Conductivity of water is its ability to allow an electric current through it and varies both with number and types of ions present in the solution which depends on the concentration of ionized substances in the water. The unit of measurement of conductivity is microsiemens per centimeter (µs/cm). The conductivity in streams and rivers depends on the geology of the area through which it passes. Areas with granite bedrock impart lower conductivity as it mainly contains inert materials that do not ionize in water unlike the areas of clay soils. Increase in conductivity would naturally signify an external source which may or may not have a polluting effect.

Apparatus: Multi water quality analyzer

Procedure: as given in section 5.1

Observation: As per given in Table No. 5.1

Turbidity: Turbidity is the degree of clarity in the water which measured by the amount of light allowed to pass through it by the suspended solids present in it. The suspended particles may include soil particles, algae, microbes, planktons and other substances. Higher turbidity results in increased water temperatures because of heat absorption by suspended particles. This results in reduced dissolved oxygen content. Higher turbidity also results in lesser penetration of light through the water, which affects the photosynthesis process and thus the oxygen content.

Apparatus: Multi water quality analyzer
Procedure: as given in section 5.1
Observation: As per given in Table No. 5.1

Total dissolved solids: It is that part of the total solids that is dissolved in water i.e. the soluble portion the solids contained in the water. Dissolved solids is usually made up by chlorides, nitrates, calcium, phosphates and other ions that are less than 2 micron in size. Deviation in the normal dissolved solids in the water may disturb the water balance in the cells of the aquatic organisms. Increase in dissolved solids may lead to pushing out of other necessary nutrients as well as decrease in the oxygen content which can have adverse implications of its own.

Apparatus: Multi water quality analyzer

Procedure: as given in section 5.1

Observation: As per given in Table No. 5.1

Table 5.1: Results of Physical parameters of the samples

Sample	TDS (g/L)	Turbidity (NTU)	Conductivity (ms/cm)	Temperature (°C)
Sample 1	0.089	45.6	0.144	22.15
Sample 2	0.274	23.7	0.449	22.36
Sample 3	0.316	31.1	0.246	24.3
Sample 4	0.483	8.1	0.757	31.03
Sample 5	0.656	10.6	1.01	31.15
Sample 6	0.416	22.6	0.653	31.34
Sample 7	0.264	8.71	1.04	30.86
Sample 8	0.241	8.03	1.00	31.52

pH: It defines the amount of acidity or alkalinity present in the water sample from a scale of 0 to 14, 0 signifying highest acidity, 14 signifying highest alkalinity and 7 being the neutral point. pH has a defining role in many of the chemical and biological processes occurring in water. The survival of living organisms in water is possible only if its pH lies certain intervals usually from 6 to 8.5. pH outside this range can stress the physiological systems of most organisms and make their survival difficult. The main significance of pH in domestic water supplies relates to its effects on water treatment.

Apparatus: Multi water quality analyzer

Procedure: as given in section 5.2

Observation: Observation: As per given in Table No. 5.2

Dissolved oxygen: It is quantity of oxygen dissolved in the water derived from the atmosphere and the aquatic plants during the process of photosynthesis. Dissolved oxygen plays a significant role in assessing the quality of water and check pollution. It helps in determining whether changes are brought about by aerobic or anaerobic organisms. It is used to find the biological oxygen demand, a parameter useful to assess the potential of wastes to get polluted. It also an important parameter that needs to be assessed before any aerobic biological treatment processes for wastewater. The amount of oxygen in boiler feed waters is controlled by DO test.

Apparatus: Multi water quality analyzer

Procedure: as given in section 5.2

Observation: As per given in table 5.2

Biochemical Oxygen Demand: The BOD test is required to measure the amount of oxygen required by organic matter for their decomposition. It gives a measure of the amount of organic matter in the water sample and their strength. It helps in assessing the pollution levels of the water sample. BOD greater than 5 mg/L signifies the water is impure. It also helps find the efficiency of effluent treatment plants by assessing their BODs at the inlet and outlet.

Principle

In this test we measure the amount of oxygen required by the organic and inorganic components in the sample for a particular amount of time at a specific temperature. The basic methodology is to measure the DO difference between the time intervals of the measurement. In this case we have kept the sample at 27°C for 3 days.

Apparatus and Chemicals:

1. BOD bottles 300mL capacity
2. Incubator or water-bath controlled at 27ºC
3. Magnesium sulphate
4. Ferric chloride
5. Calcium chloride
6. Phosphate buffer
7. Acid and Alkali solutions 1N
8. Sulphuric acid
9. Sodium sulphate solution 0.025N
10. Alkali iodide-azide reagent
11. Glucose-glutamic acid solution
12. Starch indicator
13. Nitrification inhibitor
14. Standard sodium thiosulphate (0.025N)

Procedure:

Preparation of dilution water:

1. Distilled water is used.
2. The dilution water is aerated with clean, filtered air up to DO saturation point at 27°C.
3. For every 1 L of dilution water, 1mL each of phosphate buffer, magnesium sulphate, calcium chloride and ferric chloride are added.
4. In cases where the sample is not expected to have microbial population in sufficient quantity seeding becomes essential, BOD of which is also to be determined.

Sample preparation:

1. The sample is brought down to neutralized pH of 7, if not.
2. $Na_2S_2O_3$ is added to the sample to free it form residual chlorine.
3. If nitrification inhibition is desired, 3mg 2-chloro-6-(trichloromethyl) pyridine (TCMP) is added to each 300mL bottle before capping or sufficient amount to the dilution water is added to make a final concentration of 30mg/L.
4. Where DO in the samples is greater than 9 mg/L, it treated to reduce the DO content to saturation at 27ºC.

Sample processing:

1. The diluted or undiluted sample is siphoned in three labelled bottles and stopper immediately.
2. 1 bottle is used to determine the DO and the rest 2 is kept in the incubator for 3 days at 27ºC.
3. The O_2 consumption is measured in dilution water.
4. BOD of seed blank is determined for correction of actual BOD.
5. DO of the samples can be determined using the multi water quality checker.

Calculations:

BOD of the sample is calculated as follows:

a) When dilution water is not seeded

BOD as O_2 mg/L = {(D1 –D2) x 100}/ % dilution

b) When dilution is seeded

BOD O_2 mg/L = {(D1 – D2) – (B1 –B2) x 100}/ % dilution

Where, D1 = DO of sample immediately after preparation, mg/L

D2 = DO of sample after incubation period, mg/L

B1 = DO of blank (seeded dilution water) before incubation, mg/L

B2 = DO of blank (seeded dilution water) after incubation, mg/L

Observations: As per given in table 5.2

Acidity: Acidity is an important measure as it helps in predicting corrosiveness of the water, natural or waste water. In the water softening process acidity has to be accounted for adjusting the amount of reagents to be added to the sample. In the case of industrial wastes, before they can be discharged, acidity has to be found out to determine the amount of chemicals required to neutralize the waste.

Reagents required

1. Standard sodium hydroxide solution (N/50)
2. Methyl orange indicator solution
3. Phenolphthalein indicator solution
4. Sodium thiosulphate solution (N/10)

Principle

By finding the stoichiometric equivalence point one can find the acidity of the sample. The stoichiometric equivalence point is determined by titrating against an alkali solution. Since reaching this stoichiometric equivalence point is very difficult, the titration is carried to a known end point pH. Thus to find acidity we have to find the amount of base required to neutralize the sample to a certain pH.

For mineral or weak acids, the titration has to be done up to a pH endpoint of 4.5. The indicator used is methyl orange, hence called methyl orange acidity and the color change is from red to yellow. For strong acids, the titration has to be done up to a pH endpoint of 8.3. The indicator used is phenolphthalein, hence called phenolphthalein acidity and the color changes to pink.

Procedure

Methyl orange acidity

i. 100 ml of the sample is taken in a conical flask.
ii. 1 drop of N/10 $Na_2S_2O_3$ solution is added to the sample.
iii. 2 drops of methyl orange in added.
iv. The sample is then titrated with N/50 NaOH solution till yellow color appears.
v. The volume required is recorded as A ml.

Phenolphthalein acidity

i. 100 ml of the sample is taken in a conical flask.
ii. 1 drop of N/10 $Na_2S_2O_3$ solution is added to the sample.
iii. 2 drops of phenolphthalein indicator is added.
iv. The sample is then titrated with N/50 NaOH solution till yellow color appears.
v. The volume required is recorded as B ml.

Observations and calculations:

Volume of water samples taken for each titration = 100 ml

Volume of N/50 NaOH used in presence of methyl orange indicator = A ml

Volume of N/50 NaOH used in presence of phenolphthalein indicator = B ml

Methyl orange acidity

N_1V_1 (sample) = N_2V_2 (N/50 NaOH)

$N_1 * 100 = 1/50 * A$

Or $N_1 = A / (50*100)$

Methyl orange acidity (as $CaCO_3$) = (A*50) / (50*100) g/l

= (A*50*1000) / (50*100) ppm

= A*10 ppm

Phenolphthalein acidity = (B*50*1000) / (50*100) ppm

= B*10 ppm

Observation: As per given in table 5.2

Hardness: Hardness is a measure of the calcium and magnesium content in a water sample which is responsible for the precipitation of soap. The hardness of a sample is measured in terms of equivalent $CaCO_3$ in mg/L. It impact on the human health may not be prominent but it has severe concerns in the industrial settings where it can lead to costly breakdowns in boilers, cooling towers etc.

Classification of hardness in terms of the equivalent $CaCO_3$ concentration:

Soft 0-60 mg/L

Medium 60-120mg/L

Hard 120-180mg/L

Very hard >180mg/L

The method used for the determination of Total hardness is EDTA titration method.

Principle

Hardness is determined by forming a soluble chelated complex of the metal ions with EDTA and its soluble salts which is indicated by a color change from wine red to blue.

Reagents and standards

i. Standard hard water

ii. Eriochrome Black T indicator

iii. EDTA solution (N/50)

iv. NH_4Cl- NH_4OH buffer

Procedure

a. EDTA solution is standardized with standard hard water. The volume of EDTA used is recorded as A ml.
b. 50 ml of the sample is taken in a conical flask.
c. 2 mL each of buffer solution and indicator is added to this sample.
d. The sample is then titrated against EDTA until wine red color changes to pure blue.
e. The volume of EDTA used is recorded as B ml.

Observation: As per given in table 5.2

Phosphorus: Phosphates is the primary form in which phosphorus occurs in waste and natural waters. It is among the basic elements needed for growth of plants. However, an increase in its concentration can lead to speeding of a process called eutrophication which is an increase in the concentration of mineral and organic nutrients leading to the decrease in the oxygen content in the water body.

STANNOUS CHLORIDE METHOD

PRINCIPLE: Molybdenum blue is a colored complex formed by the reduction of molybdophosphoric acid (obtained by the reaction of orthophosphates with ammonium molybdate in acidic condition) by stannous chloride. The concentration of phosphates can be measured by measuring the intensity of the blue colored complex formed as they are directly proportional.

Reagents

1. Phenolphthalein indicator aqueous solution
2. Strong acid solution
3. Ammonium molybdate reagent (AMR)
4. Stannous chloride reagent
5. Standard phosphate solution

Procedure

1) Standard solutions of 2, 4, 6, 8, 10 ppm are prepared using the standard phosphate solution in a 100 ml beaker.
2) The samples of 100 ml volume are also taken in a beaker.
3) 4ml of AMR followed by 0.5 ml of stannous chloride is added to the standard solutions and the samples and allowed to stand for 10 minutes.
4) A blank solution is prepared in the same way using distilled water.
5) The blank solution is placed in the spectrophotometer for blanking.
6) The standard solutions are then placed in the spectrophotometer and the absorbance is duly noted.
7) The absorbance of the samples are then found out.

8) A graph of absorbance vs. phosphate concentration is plotted to give a straight line passing through the origin.
9) From the graph concentration of phoshphate in the samples are found out.

Observation: As per given in table 5.2

Sulphates: High concentrations of sulphates in drinking water has a laxative effect which is enhanced when ingested in combination with magnesium. Sulphates in the form of H_2S can cause problems of odour and corrosion in waste water treatment. It can also be one of the causes of scaling in water supplies.

Principle: sulfate ion (SO_4^{2-}) is precipitated in an acetic acid medium with barium chloride ($BaCl_2$) so as to form barium sulphate ($BaSO_4$) crystals of uniform size. Light absorbance of the $BaSO_4$ suspension is measured by a photometer and the So_4^{2-} concentration is determined by comparison of the reading with a standard curve.

Reagents

1) Buffer solution
2) Barium chloride
3) Standard sulfate solution

Procedure

1) Sulphate standard solutions of 2, 4, 6, 8, 10 ppm are prepared from the standard sulphate solution in a 100 ml beaker.
2) The samples of 100 ml volume are also taken in a beaker.
3) 20 ml buffer solution is then added and mixed well.
4) 1 spatula of $BaCl_2$ is added with stirring and continued for a minute.
5) A blank solution is prepared in the same way using distilled water.
6) The blank solution is placed in the spectrophotometer for blanking.
7) The standard solutions are then placed in the spectrophotometer and the absorbance is duly noted.

8) The absorbance of the samples are then found out.
9) A graph of absorbance vs. sulphate concentration is plotted to give a straight line passing through the origin.
10) From the graph, concentration of sulphate in the samples are found out.

Observation: As per given in table 5.2

Table 5.2: Results of chemical parameters of samples

Sample	Sulphates (mg/l)	Phenolphthalein acidity(ppm)	BOD	DO (mg/L)	pH	Hardness (ppm)	Phosphates (mg/l)
Sample 1	92.77	2	2.11	10.48	5.02	100	3.179
Sample 2	177.629	20	0.88	8.85	4.45	919	3.247
Sample 3	82.592	16	1.07	7.88	4.82	85.71	3.214
Sample 4	98	12	2.7	7.83	3.6	476.19	0.17
Sample 5	86	22	1.4	7.81	6.12	500	BDL
Sample 6	189	10	1.2	7.42	4.37	414.29	BDL
Sample 7	168	28	0.86	5.95	6.85	42	2.88
Sample 8	157	4	0.03	9.14	7.02	121	2.21

Boron: Boron is found in mostly slate and loam rich rock formations entering water through the process of weathering. Boron is found in its salt form, most of which is soluble in water. Boric acid is one of the most prevalent compounds of boron. It may not be a dietary mineral for humans and animals but nevertheless they are important for the growth of plants and a few organisms as it is an important requirement in the process of mitosis. High concentrations of boron can lead to reduction of crop yield. However, trees require higher concentrations. Boron is not a dietary requirement for animals but found in the body due to plant intake. Concentrations above the permissible limit can lead to vomiting, diarrhea, nausea and blood clotting. Concentrations above 20 g can be life threatening.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Calcium: Calcium is a naturally occurring element present in water sourced mainly from rocks such as dolomite, marble, gypsum, limestone, etc. it is an important dietary constituent for all organisms especially in the bone structure. Calcium is an important constituent assisting in the normal functioning of a number of processes in the body, for instance, the nerve impulse transfer. However their deviation from optimum concentrations may lead to hazardous results. Deficiency of calcium can break or slow the cycle of various biological processes. Calcium is one the elements responsible for the hardness of water. Very hard waters cause significant problems in the industry. Their main source of pollution is from detergents used in industries.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Magnesium: Magnesium is an important dietary element like calcium. Magnesium is present in large number of minerals and gets collected during rains or when water flow through beds containing such minerals. Magnesium like calcium has an important role to play in the various biological processes. Hence its deficiency can severe health problems. Even the plants and other organisms heavily rely on magnesium for their smooth functioning. Magnesium also causes hardness of water. Hence its high concentrations can cause adverse effects on the water quality. High doses of magnesium may result in vomiting and diarrhea. Consumption of large doses of magnesium in the form medicines and food supplements may cause muscle slackening, depressions, nerve problems and personality changes.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Silicon: Silicon is the most abundant element after oxygen. It is never found in its free form because it reacts easily with oxygen to form silicon dioxide and is usually present as silicic acid in water. Silicon is present in a number of minerals and abundant in sand. It can be considered a dietary requirement for a number of organisms, required mostly for bone development and found in skin and connective tissues. Silicon compounds due to their fiber like structure are carcinogenic in nature. They cause diseases like silicosis when repeatedly exposed to high concentrations of silicon.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Arsenic: Arsenic compounds are present abundantly in the earth's crust which is released during the process of mining and from weathering to enter into the ground water. Arsenic compounds are essential for some plant and animal species in their protein synthesis. However for humans it does not have any significant benefits within the permissible limits. However outside the permissible limits it can have adverse health effects which is synonymous to poisoning. Arsenic poisoning is a common phenomenon resulting in long term chronic health effects, such as skin disease, skin cancer and tumors in lungs, bladder, kidneys and liver.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Cadmium: Cadmium is present abundantly in the earth's crust and released due to weathering. It is also released from forest fires, volcano explosions and mainly from the manufacturing units. It also released as a by-product of the extraction of zinc, lead and copper. Cadmium has adverse health effects by forming complex bonds with the proteins which eventually accumulate in the kidneys. Some of the health effects are damage to the immune system, psychological disorders, damage to the central nervous system and many more.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Cobalt: Cobalt is a hard ferromagnetic, silver-white, hard, lustrous, brittle element. It is a relatively stable element affected only by dilute acids and remains unaffected in water. It is widely dispersed in the environment but its main concentrations are in the earth's core. Cobalt being a part of vitamin B_{12} is an essential for humans and their health. High concentrations of cobalt from mining and smelting facilities can cause accumulation in plants through the human health can be affected. Some of the adverse health effects of intake of high concentrations of cobalt are vision problems, heart problems, vomiting, and nausea and thyroid damage. Cobalt and its compounds have been listed under as carcinogenic.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Chromium: The major sources of chromium pollution is from the tanning industry which utilizes chromium compounds for tanning. Chromium under certain concentrations are fine for dietary needs. However some compounds of chromium can cause extreme negative health like allergic and asthmatic reactions. Chromium is also carcinogenic in nature. Other health effects include diarrhea, stomach and intestinal bleedings, cramps, and liver and kidney damage.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Copper: Copper is an extremely common element that occurs naturally in the environment through the various natural processes. The use of copper has becomes significant in the industries and hence its concentration is increasing manifold in the environment. Copper is an important trace metal requirement of the body. However if it is over the permissible limits it can cause adverse health effects like headaches, stomach aches, vomiting, dizziness and diarrhea. Chronic copper poisoning has even more lethal impacts. It results in Wilson's disease symptoms of which is hepatic cirrhosis, brain damage, demyelization, renal disease, and copper deposition in the cornea. High copper concentrations have negative effect on the growth of plants. It affects the processes in the soils and the micro-organisms and their activities. Thus it is difficult to find much vegetation near copper disposing factories.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Iron: Iron is one of the most widely used elements because of its strength and low cost. With an increase in demand of steel, mining of iron ore has increased manifold. With more steel production and iron ore mining, iron concentrations are bound to increase which is all the more reason to be concerned about. Iron is present in hemoglobin which makes it an important element for the human body. However its retention in the tissues may lead to conjunctivitis, choroiditis and retinitis. Its deficiency leads to a disease called anemia which is the decrease in the amount of red blood cells.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Manganese: Manganese compounds are abundantly found in soils. They are enormously useful in a variety of processes and industries. Its use in the steel making, ceramic industry, as oxidizers, disinfectants, in fertilizers etc. make its more the reason to found in more than appreciable concentrations in the environment. Manganese is one of the 3 essential toxic trace elements i.e. the deficiency of this toxic element could cause adverse effects. Its deficiency can cause fatness, glucose intolerance, blood clotting, skin problems, lowered cholesterol levels, skeleton disorders, etc. Over exposure to manganese mainly affects the respiratory tract and brain functions. Manganese poisoning leads to hallucinations, forgetfulness, and nerve damage. It also cause Parkinson, lung embolism and bronchitis. The dose level for animals is very low, hence their chances of survival in high manganese concentration environment becomes difficult. In plants it is required for the conversion of water to hydrogen and oxygen, hence very essential.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Nickel: Nickel is not that abundantly found on the earth's surface. It is mainly found in the earth's core which is inaccessible. It used in making alloys, stainless steel, batteries, catalysts etc. Nickel is essential for the human body only in small concentrations. Exposure to nickel is from smoking cigarettes, tea and vegetables. High levels of nickel can lead to respiratory failure, asthma and chronic bronchitis, heart disorders, increased chances of cancer, allergic reactions, etc. High levels of nickel concentrations can damage plants and in water they affect the algae growth.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Lead: Lead is rare in its native form. Thought they occur naturally, they present mostly due to human activities. It is found while mining for zinc, silver and copper. Its pollution is a very severe threat and is a worldwide issue. Lead is used in car batteries, paints and ceramics and easily exposed to the human body. Lead seems to present no essential function in the body. However it can cause a lot of adverse effects some of which are rise in blood pressure, kidney damage, disruption of nervous system, brain damage, psychological disturbances, disruption of the biosynthesis of hemoglobin and anemia. Lead enters in to waters and soils through corrosion of leaded pipelines.

Apparatus: Atomic Absorption Spectroscopy
Procedure: as given in section 5.28
Observations: As per given in Table No. 5.3

Selenium: Selenium is a non-metallic element and among the rarest of the elements, even rare than silver. Selenium finds it use in electronics in making photocells and solar cells. It is also widely used in the glass industry as a coloring agent or a color removing agent. Selenium essential in maintaining the health. Its deficiency can cause heart and muscle problems. High levels can cause various health effects like brittle hair, deformed nails, rashes, skin swells and severe pains. Selenium poisoning in extreme can cause death. Selenium effects on the environment depend on the nature of interaction with other compounds.
Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Zinc: Zinc is usually found in its metal form. It ends up in water mainly through mining of zinc ores and the rest from the different industries such as galvanizing industries. Zinc salts can cause turbidity in water in higher concentrations and add an unwanted flavor to the water. It has a dietary value as trace element and involved in the processes relating to enzymes and DNA replication. Deficiency of zinc can lead to tastelessness and loss of appetite. High doses of zinc lead to nausea,

vomiting, dizziness, fevers and diarrhea. Zinc helps in protecting people from cadmium poisoning and also decrease lead absorption.

Apparatus: Atomic Absorption Spectroscopy

Procedure: as given in section 5.28

Observations: As per given in Table No. 5.3

Table 5.3: Results for various parameters using AAS

Parameters	SL-1	SL-2	SL-3	SL-4	SL-5	SL-6	SL-7	SL-8
Boron	BDL	BDL	BDL	BDL	BDL	0.019	0.446	0.073
Calcium	11.43	62.04	15.88	70.38	67.52	45.4	17.9	34.7
Magnesium	8.755	48.14	19.02	30.45	31.18	38.9	86.3	24.1
Silicon	0.164	3.552	3.673	5.474	5.18	5.465	6.39	4.212
Arsenic	BDL	BDL	BDL	0.032	0.042	0.026	0.001	0.001
Cadmium	0.005	0.006	0.004	0.004	0.007	0.005	0.004	0.003
Cobalt	0.006	0.197	0.011	0.008	0.011	0.014	0.013	0.015
Chromium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.007
Copper	BDL	BDL	BDL	0.032	0.026	0.046	BDL	BDL
Iron	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Manganese	BDL	1.663	BDL	BDL	BDL	BDL	BDL	BDL
Nickel	BDL	0.334	BDL	BDL	BDL	BDL	BDL	0.008
Lead	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Selenium	0.037	0.036	0.016	0.115	0.079	0.115	0.07	0.087
Zinc	BDL	0.076	BDL	BDL	BDL	BDL	BDL	BDL

Sodium: Sodium is an important dietary mineral that ends up in naturally in water from rocks and soils. Sodium is present mainly in its compound form. In its elemental form, it comes class 2 hazard i.e. it is extremely harmful. Sodium compounds are naturally present in water but their concentrations can vary depending on the geology and the level of contamination. Sodium in the body regulates the nerve functions, maintains the balance of acids and bases and also regulates the cellular fluids. Increased intake of sodium may result in high blood pressure, arteriosclerosis, oedema, hyperosmolarity, confusion, increased risk of infection, etc. Its shortage however results in dehydration, convulsion, muscle paralysis, decreased growth and general numbness. Sodium salts has many uses in the mining industry, for example in water treatment including softening, disinfection, corrosion control, pH adjustment, coagulation etc.

Apparatus: Flame Photometry

Procedure: as given in section 5.31

As per given in Table No. 5.4

Potassium: Potassium like sodium is an important dietary mineral occurring in water from the minerals during the weathering process. It is very reactive in its elemental form and thus very harmful. Potassium in association with sodium maintains the integrity of the nervous system. The help in maintaining the fluid balance in the cell. Increased levels of potassium in the body could lead to hypertension, adrenal insufficiency, coronary artery disease, etc.

Apparatus: Flame Photometry

Procedure: as given in section 5.31

Observation: As per given in Table No. 5.4

Table 5.4: Results for sodium and potassium using flame photometry

SAMPLE NO.	SODIUM	POTASSIUM
SAMPLE 1	3.791	0.29
SAMPLE 2	3.791	16.63
SAMPLE 3	5.382	3.885
SAMPLE 4	3.198	10.19
SAMPLE 5	24.75	10.06
SAMPLE 6	21.52	14.81
SAMPLE 7	21.5	12
SAMPLE 8	13.65	6.22

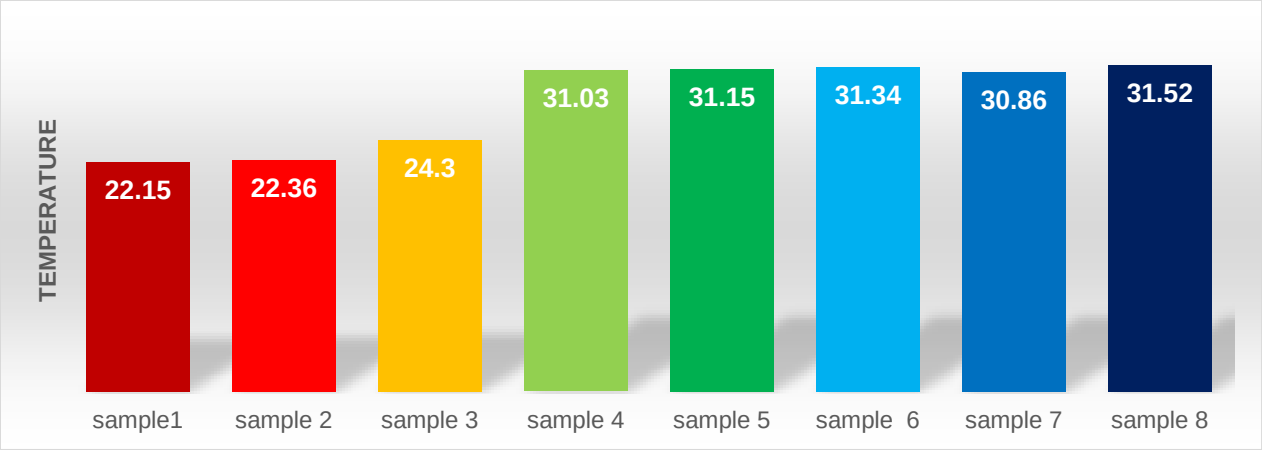

FIG-5.1 Temperature variation of samples

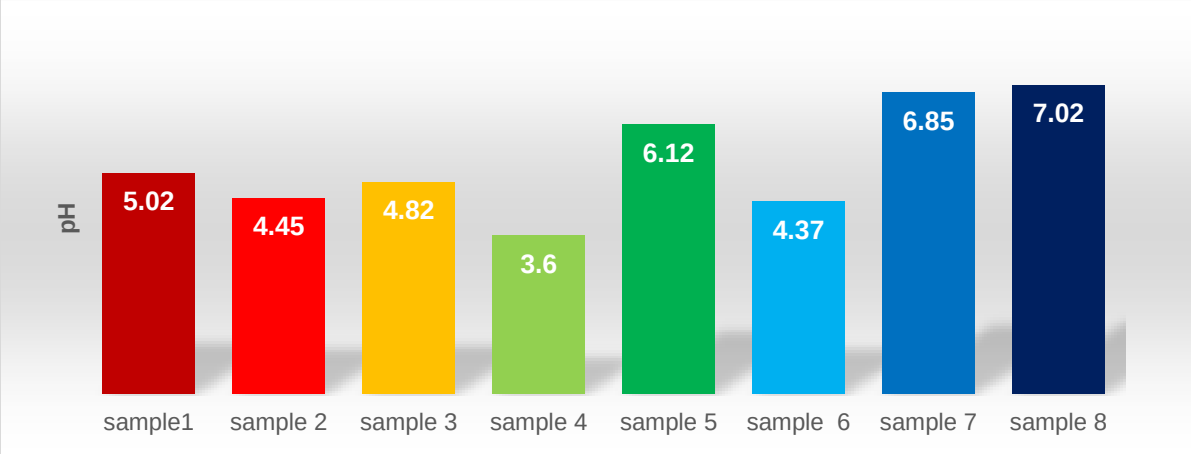

FIG-5.2: pH variation of samples

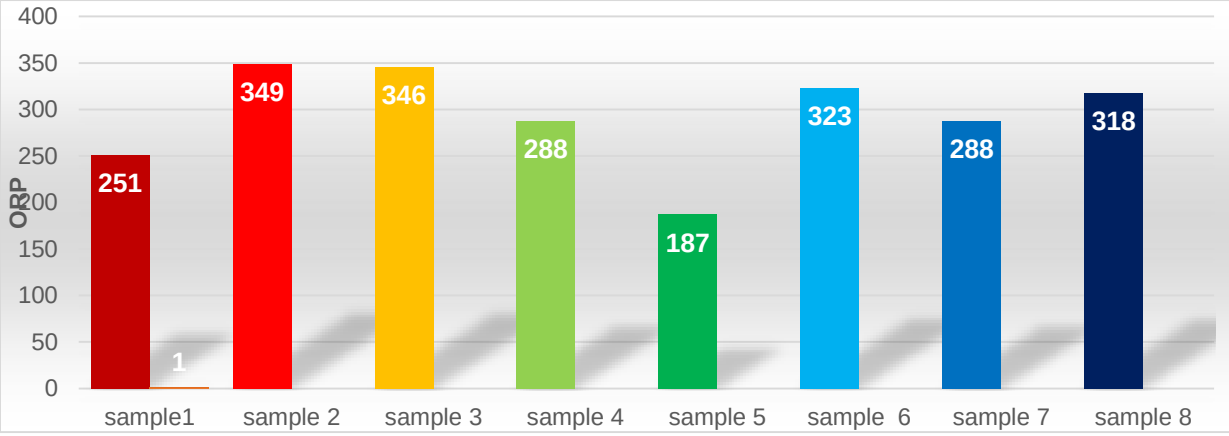

FIG-5.3: ORP variation of samples

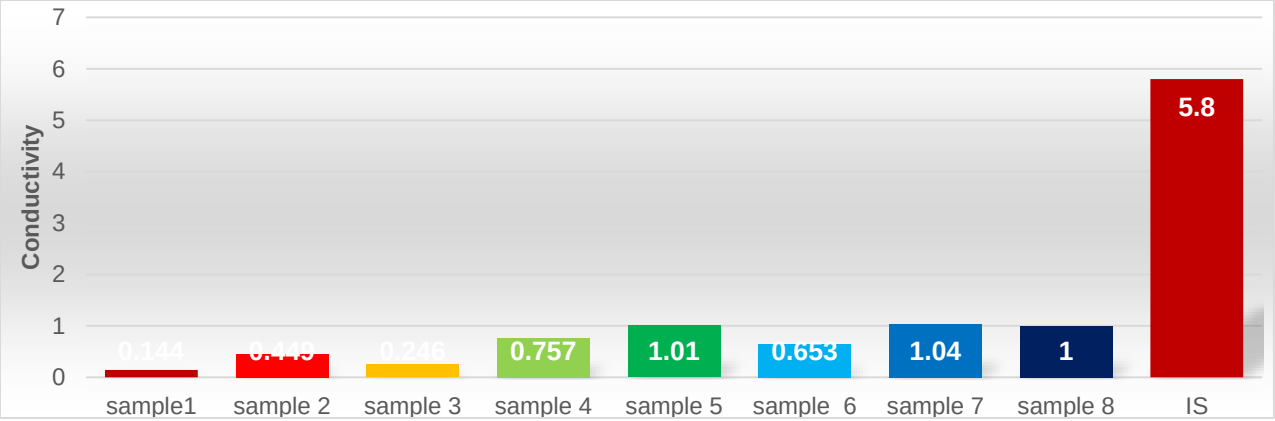

FIG-5.4: Conductivity variation of samples against Indian Standards (IS)

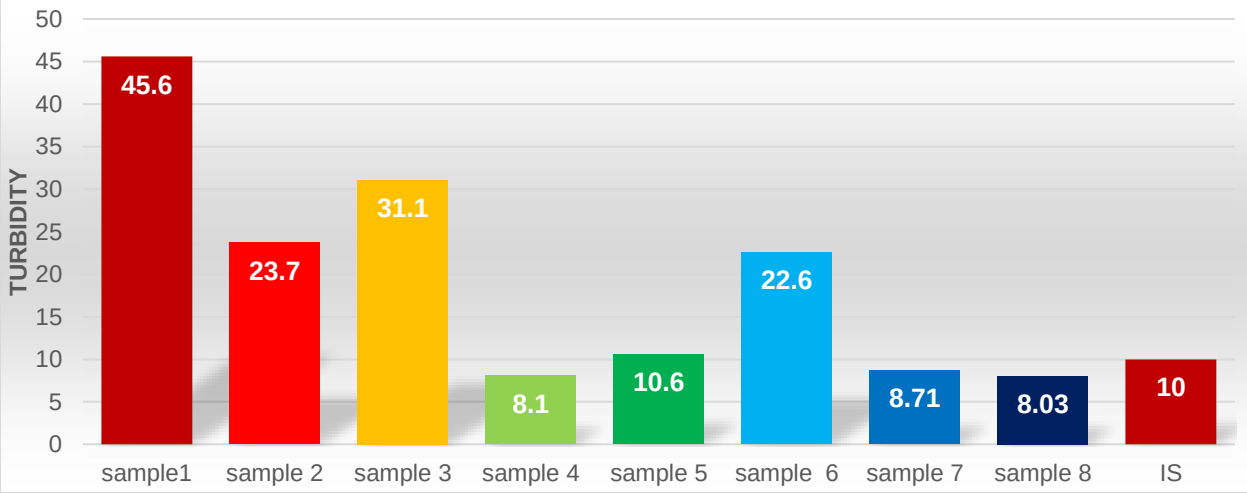

FIG-5.5: Turbidity variation of samples against Indian Standards (IS)

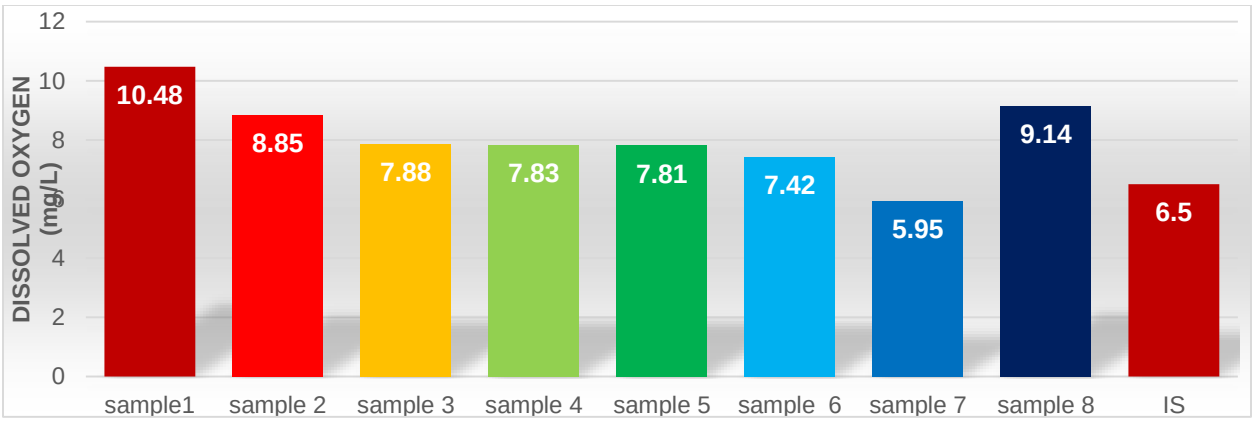

FIG-5.6: DO variation of samples against Indian Standards (IS)

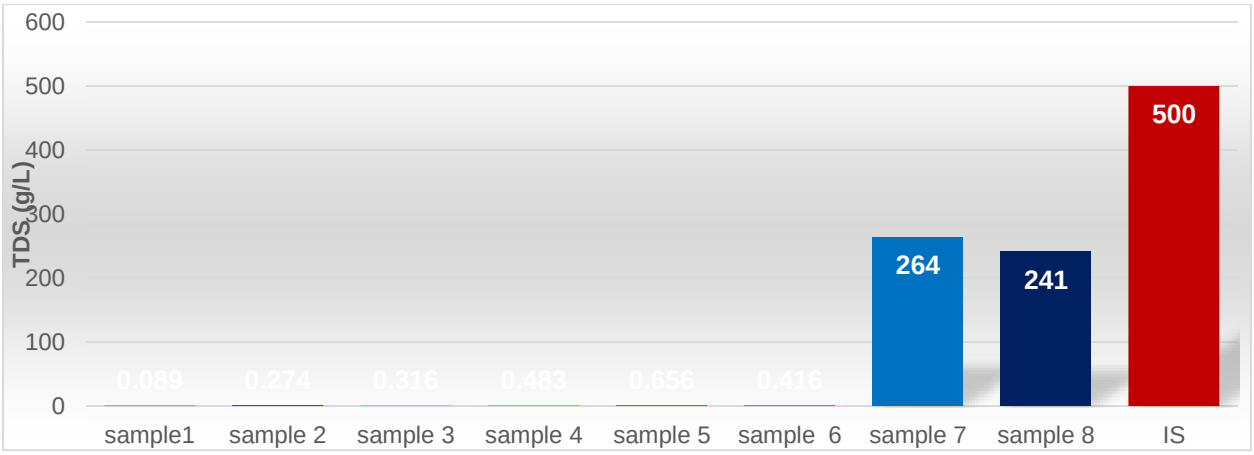

FIG-5.7: TDS variation of samples against Indian Standards (IS)

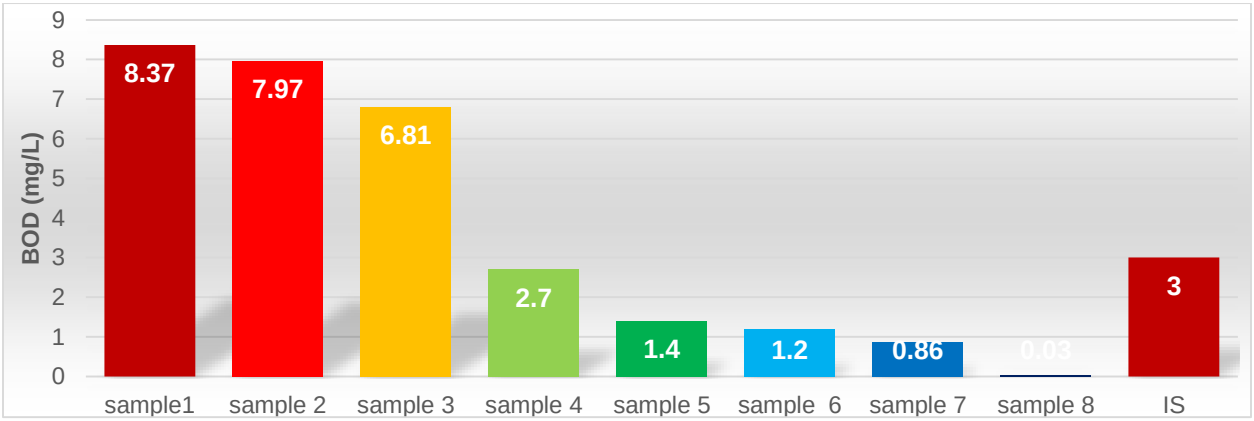

FIG-5.8: BOD variation of samples against Indian Standards (IS)

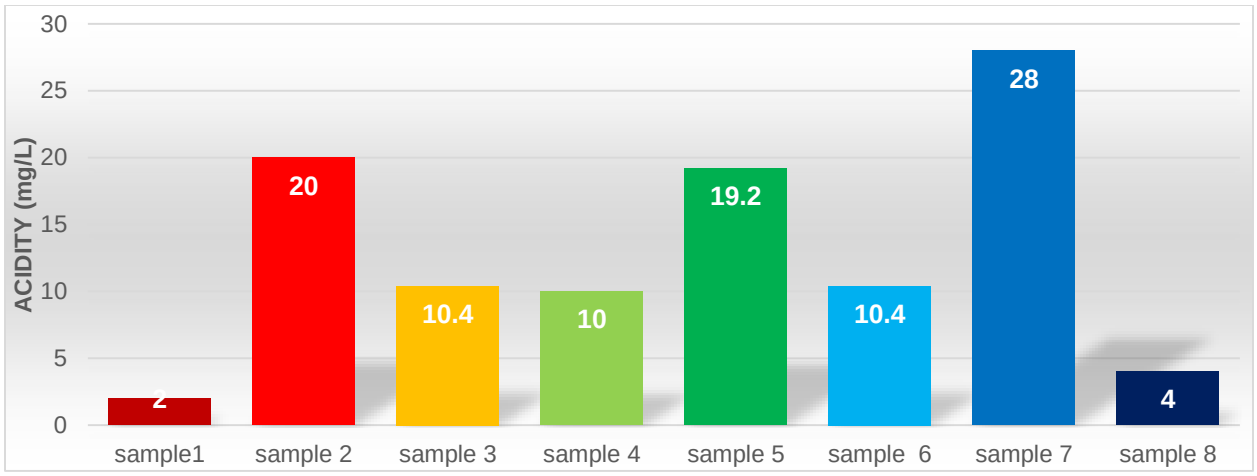

FIG-5.9: Acidity variation of samples

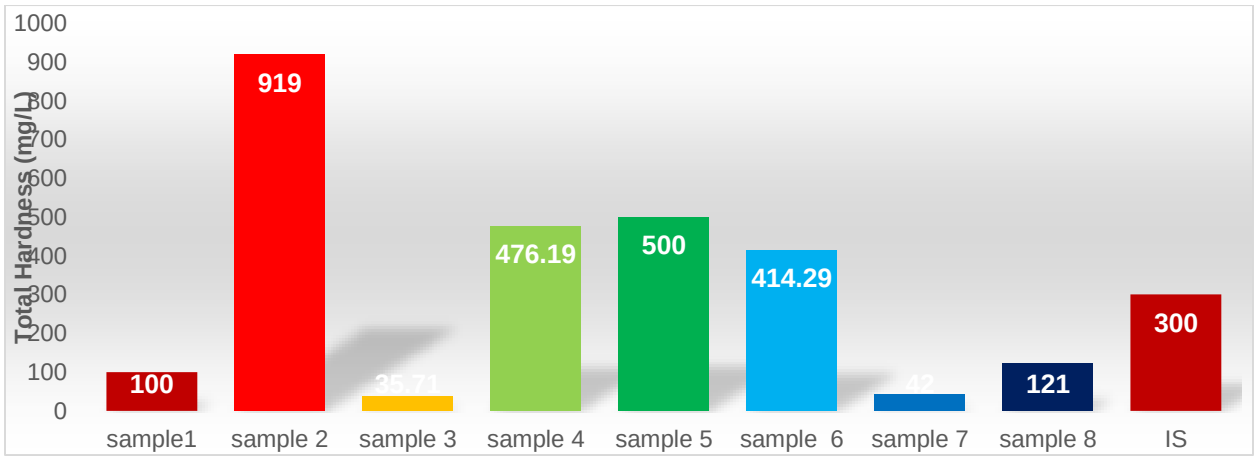

FIG-5.10: Total Hardness variation of samples against Indian Standards (IS)

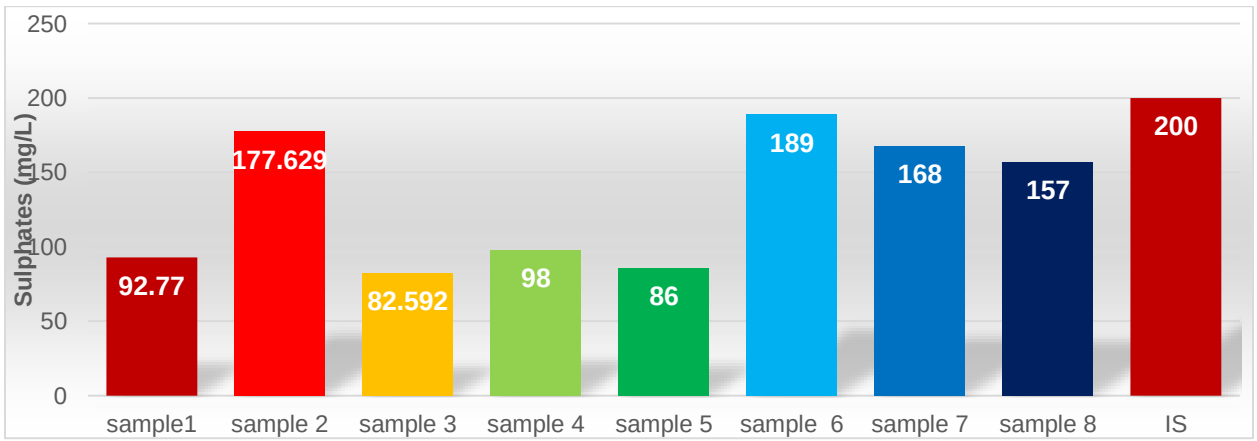

FIG-5.11: Sulphate variation of samples against Indian Standards (IS)

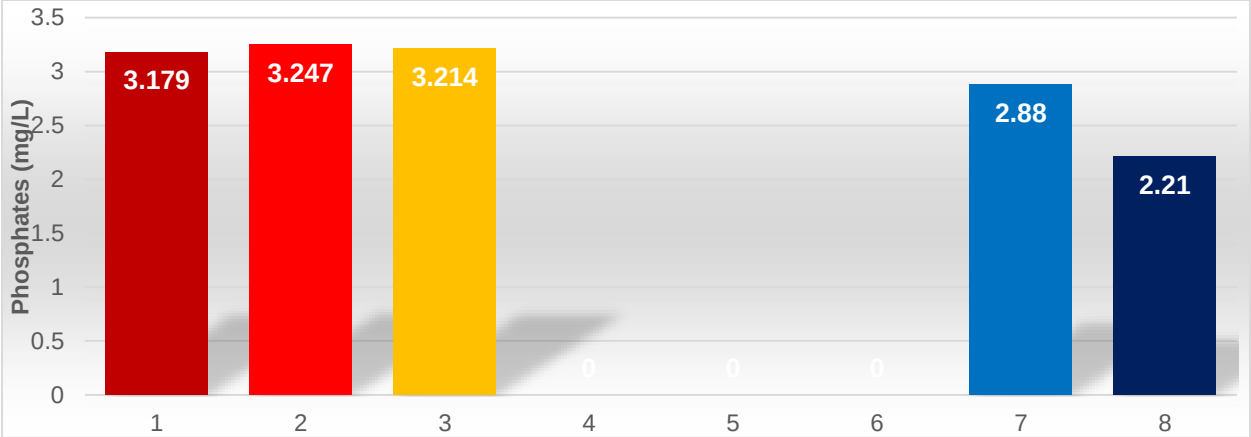

FIG-5.12: Phosphate variation of samples

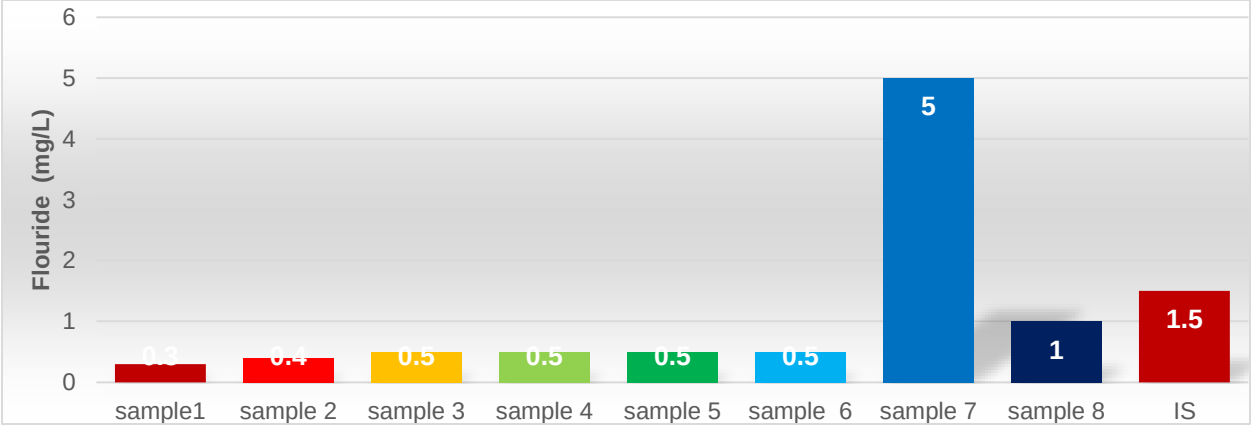

FIG-5.13: Fluoride variation of samples against Indian Standards (IS)

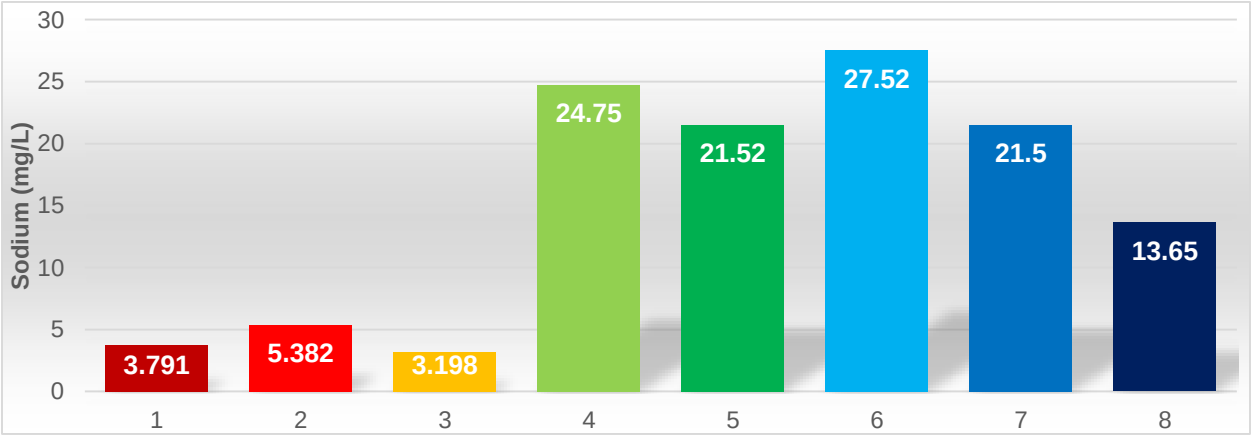

FIG-5.14: Sodium variation of samples

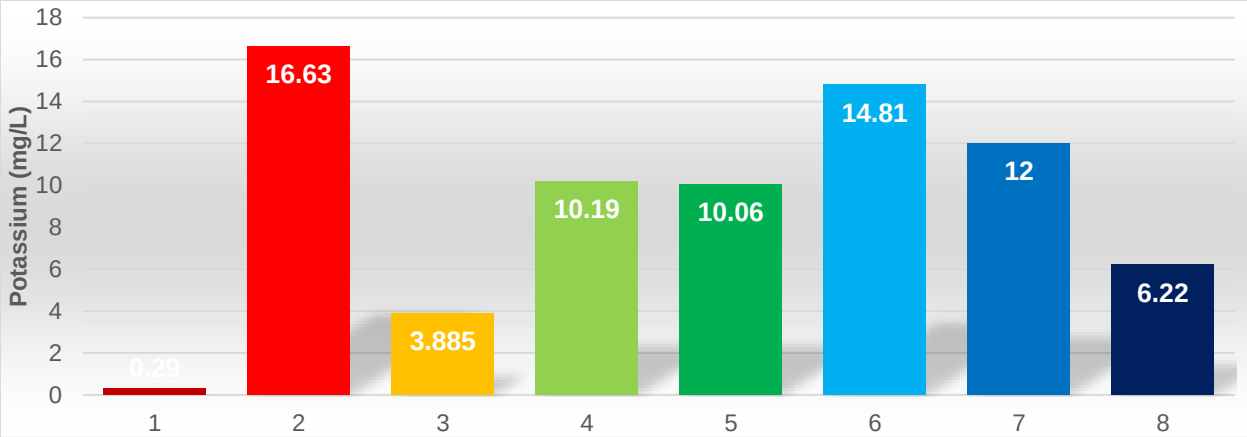

FIG-5.15: Potassium variation of samples

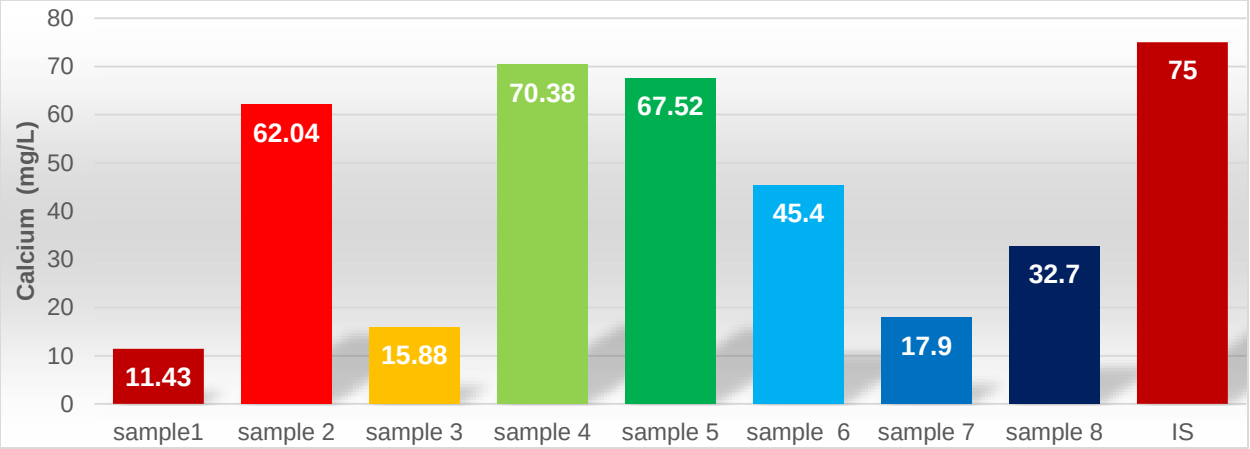

FIG-5.16: Calcium variation of samples against Indian Standards (IS)

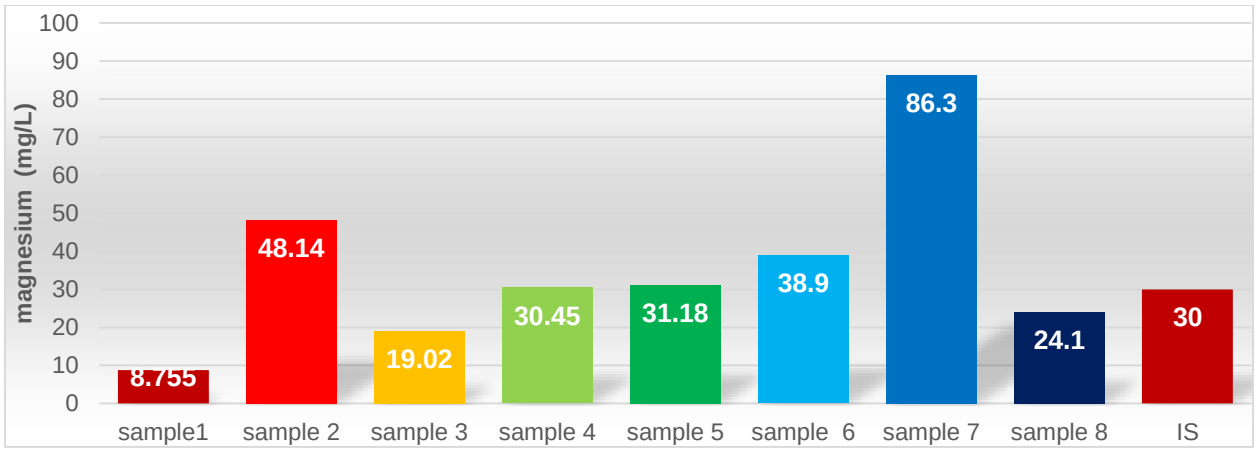

FIG-5.17: Magnesium variation of samples against Indian Standards (IS)

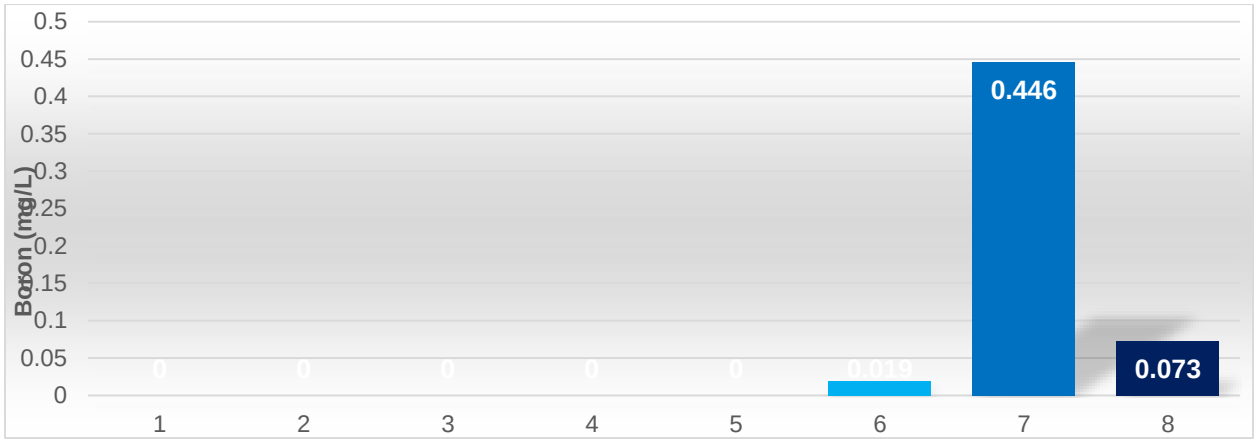

FIG-5.18 Boron variation of samples against Indian Standards (IS)

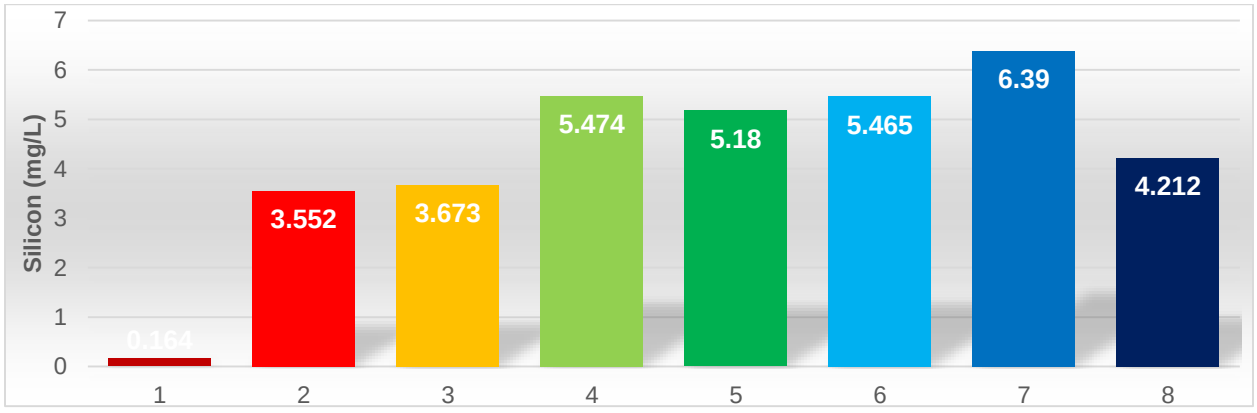

FIG-5.19 Silicon variation of samples

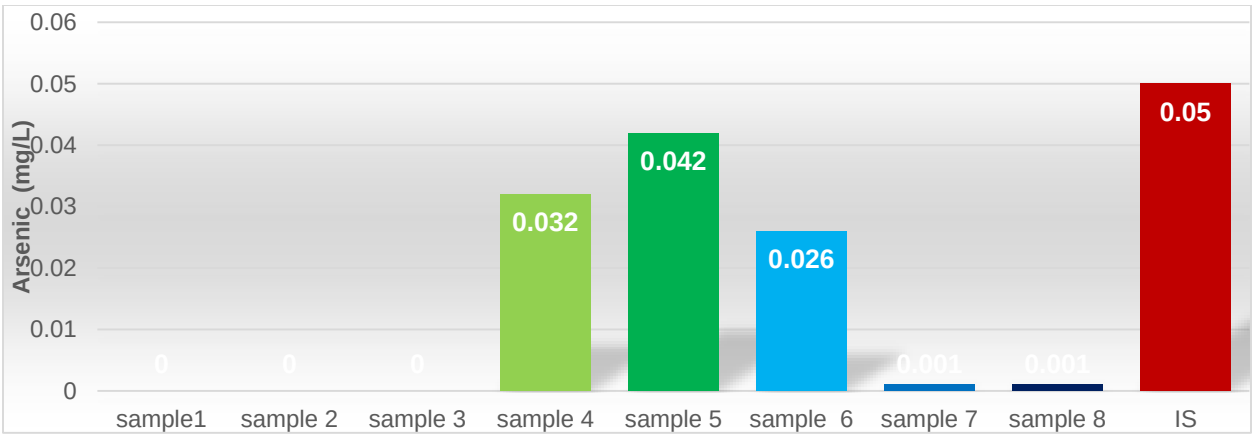

FIG-5.20 Arsenic variation of samples against Indian Standards (IS)

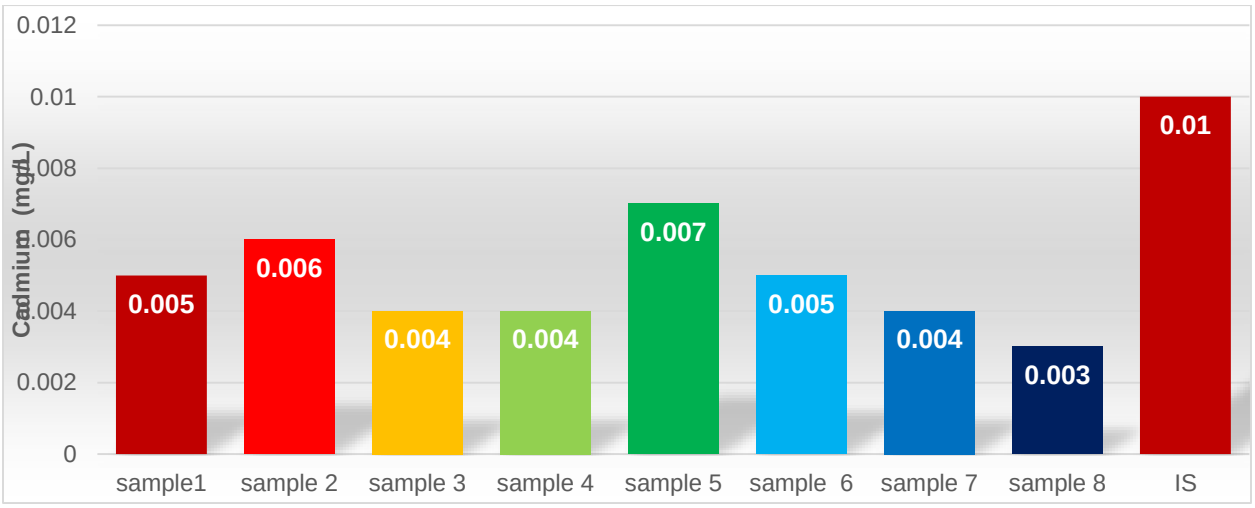

FIG-5.21 Cadmium variation of samples against Indian Standards (IS)

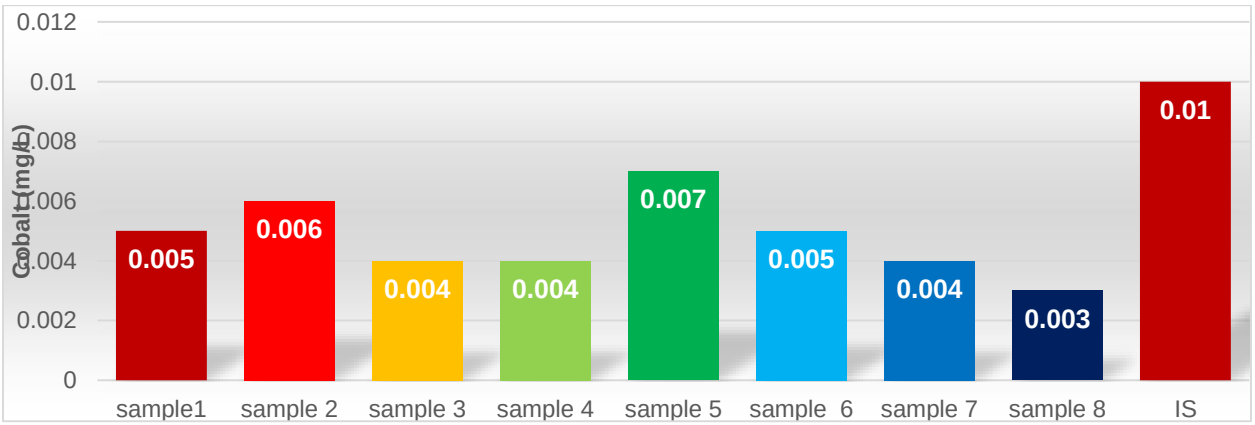

FIG-5.22 Cobalt variation of samples against Indian Standards (IS)

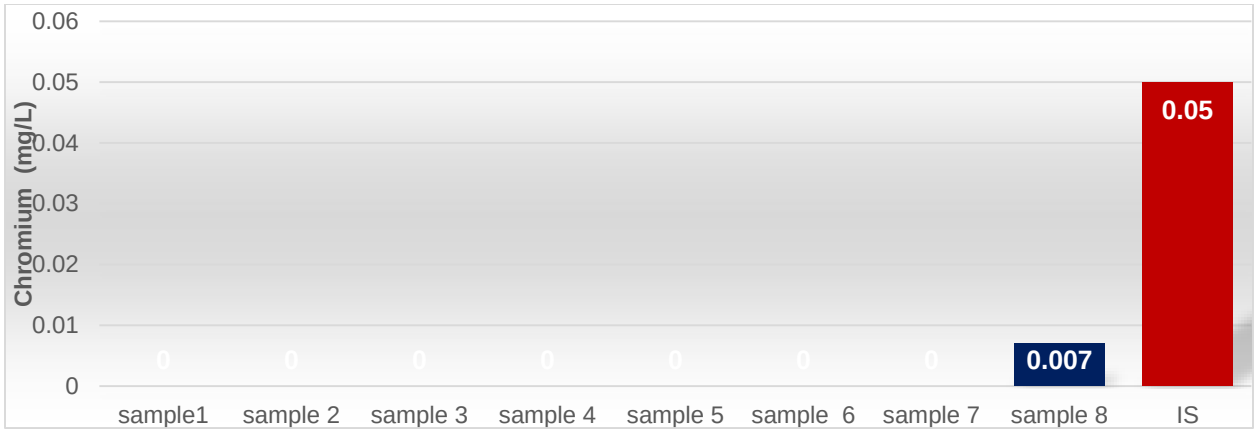

FIG-5.23 Chromium variation of samples against Indian Standards (IS)

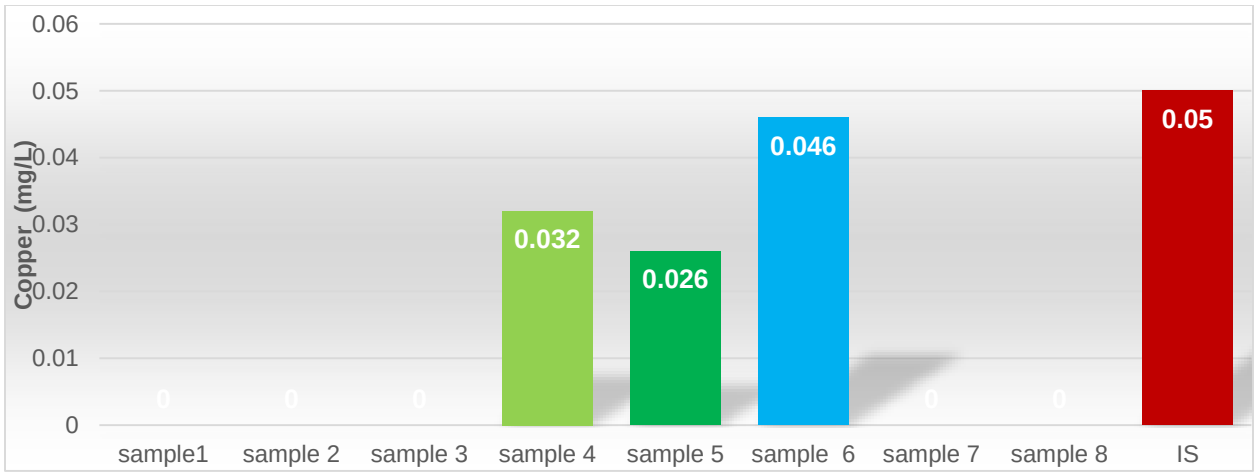

FIG-5.24 Copper variation of samples against Indian Standards (IS)

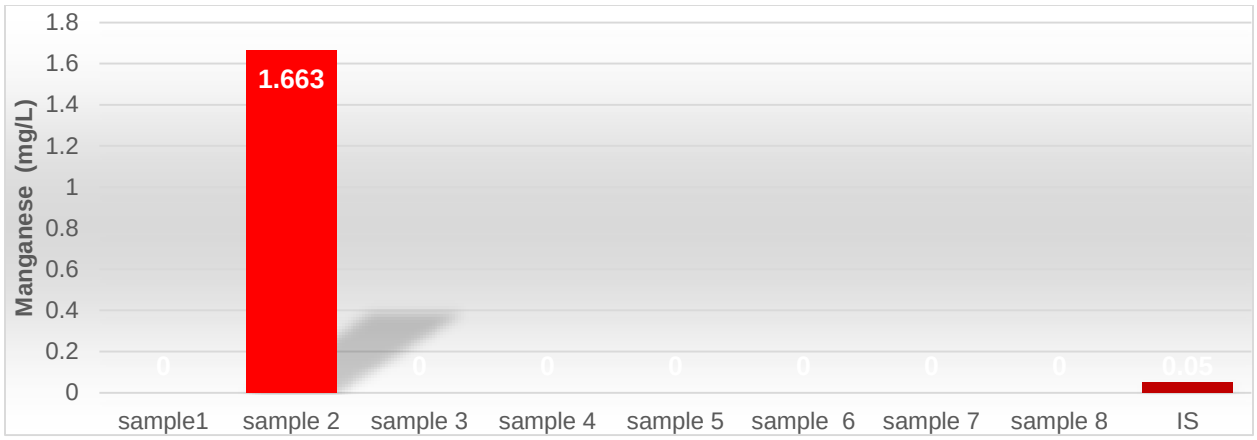

FIG-5.25 Manganese variation of samples against Indian Standards (IS)

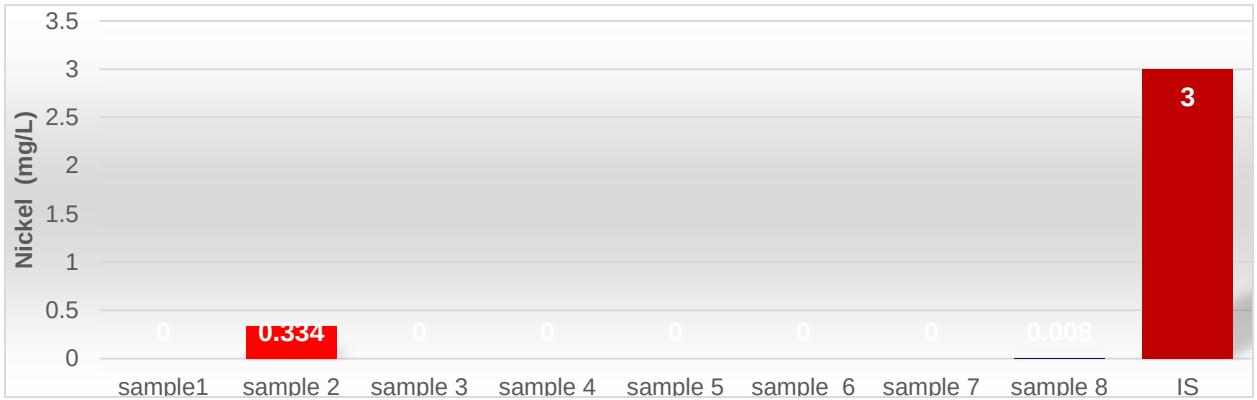

FIG-5.26 Nickel variation of samples against Indian Standards (IS)

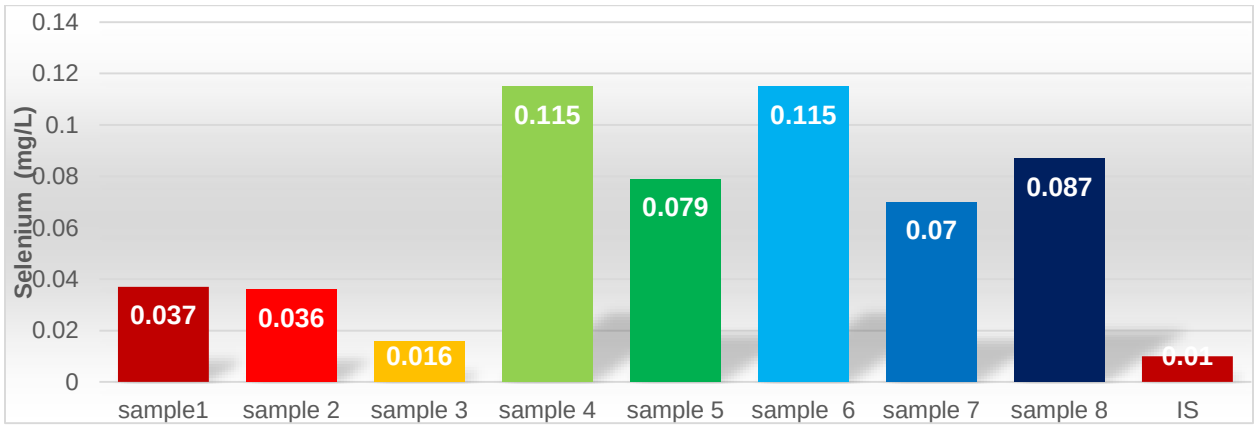

FIG-5.27 Selenium variation of samples against Indian Standards (IS)

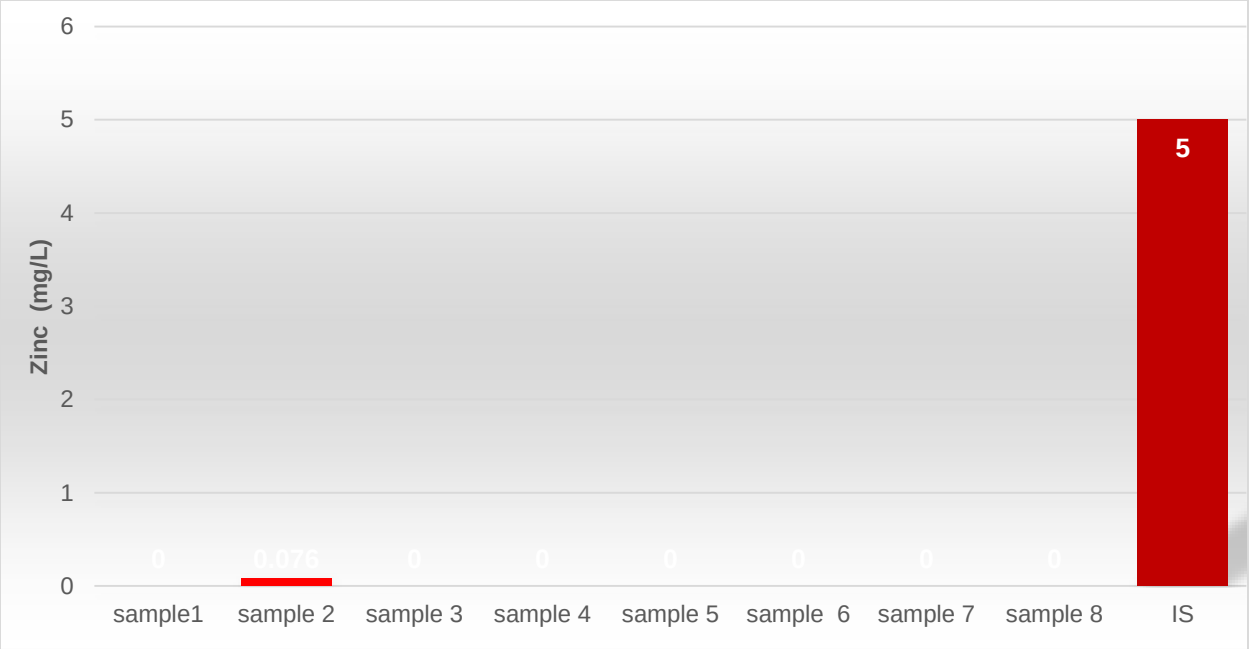

FIG-5.28 Zinc variation of samples against Indian Standards (IS)

CHAPTER 6

DISCUSSION AND CONCLUSION

6. DISCUSSION AND CONCLUSION

6.1 Discussion

The mining industry has been expanding at a rapid rate keeping in mind the demand of the present day. For this bigger, stronger and faster machines and equipment have been invented to keep pace with the demand. Technological developments have been taking place and with it, concerns about the future of the planet. This has flagged greater safety and environmental protection measures to check the pollution caused by the mining industry. The measures taken with respect to water pollution is commendable but we still have a long way to go before we can pull the planet out of the critical situation it is presently in. The analysis was carried out using certified instruments namely multi water quality analyzer, flame photometry and atomic absorption spectrophotometry. Indian standards were used to compare the concentrations of various parameters and accordingly assess the danger each element pose to the environment.

From the observation tables we find that

- The water samples from both the mines are acidic in nature i.e.
- The BOD values of water samples from both mines signify impure water.
- The total dissolved solids in downstream nallah of second mines is high and beyond permissible limits.
- The waters of both mines have high hardness values beyond the permissible limits.
- The selenium concentrations in water samples of both mines are relatively high and exceeding the permissible limits.
- The manganese concentrations in the downstream nallah of first mines is alarmingly high and more than 10 times the permissible limits.
- The rest of the parameters for both mines seem to be below the permissible limits.

6.2 Conclusion

The management of both the mines have done well to keep the concentrations of most of the parameters within the permissible limits. However they still have to be vigilant, since some of the parameters are falling outside the permissible range. The acidic nature of the water is mainly due to the pyrite content contained in the coal. The high selenium concentrations may be due the presence of selenium in the overburden and soil material. Soil testing should be carried out to verify this.

It clearly shows that coal mining has certain impact on the water quality. The low pH values, high selenium concentrations and certain anomalies in some samples are testimony to it. Since awareness and restriction with regard to water quality has already been put in place by the regulatory authorities, the impact here is not as profoundly seen as the coal mining process can have.

CHAPTER 7

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7. REFERENCES

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